THE

MINING MAGAZINE:

DEVOTED TO

Mines, Mining Operations, Metallurgy, &c., &c.

EDITED AND CONDUCTED BY

WILLIAM J. TENNEY,

VOLUME SEVEN.

FROM JULY TO DECEMBER, 1856.

New York:
PUBLISHED AT 379 BROADWAY.
John F. Trow, Printer, 377 & 379 Broadway.
1856.

INDEX TO VOL. VII.

FROM JULY TO DECEMBER, 1856.

PAGE

L

M

N

O

P

Q

R

S

vii

THE

MINING MAGAZINE.

EDITED AND CONDUCTED BY

WILLIAM J. TENNEY.

CONTENTS OF NOS. I. & II., VOL. VII.

ARTICLES.

COALS AND COLLIERIES.

Contents.

IRON AND ZINC.

JOURNAL OF GOLD MINING OPERATIONS.

JOURNAL OF COPPER MINING OPERATIONS.

JOURNAL OF SILVER AND LEAD MINING OPERATIONS.

THE

MINING MAGAZINE:

DEVOTED TO

Mines, Mining Operations, Metallurgy, &c., &c.

VOL. VII.—JULY & AUG., 1856.—Nos. I. & II.

Art I.—PROCESSES FOR THE DISTILLATION AND PURIFICATION OF THE PRODUCTS OF COAL. By C. B. Mansfield. No. 3.

[Continued from page 391, Vol. VI.]

There are other substances which may be considered as impurities, viz., naphthaline, a solid hydrocarbon, which, when pure, boils at 212 degs., and is therefore found chiefly in the camphole, and in the first half of the dead oil. Paranaphthaline, a solid hydrocarbon, which boils at a temperature above 300 degrees, and is therefore chiefly in the last portions of the dead oil. Besides these, the most volatile of the spirituous substances, viz., alliole, since it has an ill smell, may be considered as an impurity, when present in such benzole, as is required to be pure, all these, viz., naphthaline, paranaphthaline, and alliole, are removed by a sufficient quantity of concentrated sulphuric acid, which forms peculiar compounds with them, which it dissolves and carries with it to the bottom of the other hydro-carbonaceous spirituous substances, on which, with the exception of camphole, it acts much less powerfully.

I proceed now to the application of these facts to the purification of the different oils and spirituous substances manufactured according to the first part of my invention. If a very volatile spirit be required, which is not required to be entirely free from a slightly disagreeable smell, I take any portion of the most volatile part of the naphtha, separated according to the principles which I have set down; but I prefer to take for this purpose such as may have been distilled over, before the temperature in the retort in the second or third distillation, or in the last distilling vessel, if a complex rectifying apparatus be used, has risen above 80 deg. This spirituous substance, which I call alliole, will not be absolutely pure, being mixed with a certain portion of the benzole, but will usually be found to be characterized by the peculiar smell of the pure alliole. I add to this alliole about one-fourth its bulk of a cold moderately dilute acid, for which purpose I prefer hydrochloric acid of specific gravity 1·16, mixed with five times its bulk of water; but a much stronger hydro-

chloric acid may be used, or oil of vitriol mixed with nine times its bulk of water. I do not state that these preparations are absolutely necessary, but they are convenient, the requisite condition being, that the acids be not concentrated nitric or sulphuric acid; since these acids, when concentrated, destroy the alliole in proportion to the quantity in which they are used. I agitate the alliole with the acid in a suitable vessel, which should be nearly closed, or so constructed as to prevent evaporization of the spirituous substance for a length of time, which will vary with the quantity of spirituous substance which is under treatment; all that is necessary being to keep the acid and spirituous substance in a state of intimate mixture for a sufficient time, to enable the acid to form salts with the ammonia and oily alkaloids, which accompany the crude alliole; I then allow the vessel to stand undisturbed, till the two fluids have separated; I then draw off the acid liquor, and wash the alliole by agitating it with about its bulk of clean water in the same manner as with the acids. The alliole, if then allowed to separate from the water and drawn off, is fit for use. But it is convenient sometimes to rectify it again, and to allow it to stand for some time, after careful separation from any water that may accompany it, upon fresh-burnt lime, which will remove any acid and water that may still adhere to it.

The spirituous substance so obtained will be found to have a slightly alliacious odor, somewhat resembling that of bisulphuret of carbon, to be extremely volatile, and if placed in a retort and distilled, should begin to boil about 65 degs. or 70 degs.; and the greatest portion of its bulk should distil over before the temperature from the retort arrives at 80 degs., and the temperature should then rise very fast, and the retort should be dry at about 90 degs. or a little above. This spirituous substance will be found to be an excellent solvent of caoutchouc, gutta-percha, and many of the resins; it will mix with pyroxylic spirit in equal proportions, if the spirit be not too much diluted with water, and may be used when so mixed for dissolving shell-lac, or shell-lac and gutta-percha, or caoutchouc mixed, though it will not dissolve lac in sufficiently large quantities when alone, or it may be mixed with a solution of lac in pyroxylic spirit in similar proportions. And the proportions in which it may be mixed with any sample of pyroxylic spirit may be readily ascertained, by putting a known quantity of the alliole into a graduated glass, and pouring it into the pyroxylic spirit, at the same time shaking the mixture until the whole of the alliole is dissolved, and a clear transparent mixture results, which shows no streaks of milkiness when the surface in an open glass is slightly blown upon. The proportion or quantity of spirit which has been added to the alliole which was in the glass, shows the proportions in which they may be mixed. Alliole so prepared also yields a brilliant light when burned by the aid of a current of air. Next of the purification of benzole

prepared from coal tar or the products of coal tar. If this be not required perfectly free from the odor of alliole, and if moderate purity be only required, I treat this spirit in the same manner which I have described for the treatment of alliole; and if it be required for burning with the aid of a current of air, as hereinafter described, I prefer to treat it in this manner, by which all the spirituous substance is preserved intact, while the picoline and other basic or alkaline substances, which chiefly cause the disagreeable smell of the naphtha, are removed; and I consider it sufficiently pure for this purpose when a piece of white deal, dipped first into the benzole and then into hydrochloric acid, does not acquire a red or pink color. If, however, a volatile substance be required as a solvent, or for any other purpose where freedom from an unpleasant odor is necessary, the treatment is different. Instead of agitating the benzole with dilute acid, I agitate it with concentrated sulphuric acid, in the proportion of about one half pound of acid to a gallon of the benzole, which destroys the alliole, at the same time that it removes the basic oils, and oxidizes any of the brown forming substance which may be present; and I prefer to add with the sulphuric acid a small portion of the nitrate of potash, or nitrate of soda, about one ounce to half a pound of sulphuric acid, or nitric acid, or nitrous acid, or aquafortis of specific gravity about 1.30, in the proportion of one fluid ounce to half a pound of sulphuric acid; the addition of nitric acid tends greatly to bring out the pleasant smell of the benzole from the more perfect oxidation of oxidable substances which are present, and from the formation of a small quantity of the sweet-smelling compound, of which I have already spoken, which, when the benzole is rectified, is separated in the residue; or instead of sulphuric acid, mixed with nitric acid or its salts, I use nitric acid, nitrous acid, or aquafortis alone, of specific gravity about 1.30 or 1.40, or nitric acid mixed with hydrochloric acid, or nitro-muriatic acid, in the proportion of half a pound of the acid to a gallon of the benzole, or instead of the nitrate of potash or soda, I use a similar proportion of bichromate of potash. I then, after agitation, allow the mixture to settle, and then draw off the benzole from the thickened acid. I then sometimes add to the benzole a small quantity of the chloride of lime and some moderately strong acid, and stir the mixture, but this further deoxidizing process is seldom necessary. And whether this last process be used or not, I now agitate the benzole with water and complete its purification in the same manner as the alliole is purified. The spirituous substance so obtained will be found to be very volatile; if placed in a retort, it should commence to boil at 80 degs., and the largest portion of it should come over before the temperature in the retort reaches 85 degs., and the retort should be dry at 100 degs. without leaving any residue. If subjected to a temperature of 20 deg. below 0 degs. (—20 degs.) it should de-

posit so large a quantity of crystalline matter as to become almost entirely solid. It should have a smell somewhat like that of almonds. It will be found to be an excellent solvent for the same purposes as alliole, being very useful for making many kinds of varnishes. If a solution of gutta-percha be made in benzole, and the solution be spread as a varnish on a smooth surface, such as glass or porcelain, the spirituous parts will rapidly evaporate, and will leave the gutta-percha in a tough film on the surface, which must be peeled off, and in this way, by properly adjusting the surface and carefully peeling off the varnish, artificial membranes applicable to many useful purposes may be made, or by spreading the solution on the surface of the human body, an excellent plaster or artificial skin may be obtained in cases in which protection is desirable. This benzole is an excellent solvent for camphor, essential oils, fats, wax, and many other substances. It may be used as a substitute for spirits of wine in some of the arts, and for oil of turpentine in most of the purposes to which that hydrocarbon is applied, having the property of far greater volatility than the latter substance, which in many instances would be an advantage. Benzole admits, however, of yet further purification, which for some purposes it is desirable to effect, and this is accomplished by freezing. But since for those purposes for which it would be required to be so highly rectified, it would probably be required to be as free as possible from all foreign oily matters, I recommend that it be again treated with sulphuric acid, with or without the addition of saltpetre or nitric acid, or with nitric acid alone, or with nitro-muriatic acid, as above described, or that it be distilled with about one quarter its bulk of a mixture of two parts concentrated sulphuric acid and one part of a concentrated aqueous solution of bichromate of potash, or with a small quantity of chromic acid; and I recommend that such treatment be repeated until the benzole, on being agitated with cold oil of vitriol, no longer confers a dark color upon the acid; but strong nitric or nitro-muriatic acids must not be used in so large proportion as sulphuric acid may be used, since the benzole may be decomposed by the former acids, though not by the sulphuric acids.

When this further treatment with acid has been used, I wash the benzole well with water or with lime-water to remove the acid, and distil it either with or without the addition of some lime, and I prefer to insert a thermometer in the retort, and to receive for refrigeration what comes over, while the temperature in the retort is between 79 degs. and 88 degs. What comes over beyond may be mixed with some of the crude spirituous substances, reserved as purified toluole, of which it will partly consist. The benzole may be further rectified by distillation any number of times, and that portion of the distillate should always in that case be reserved separately for purification, which comes over between 80 degs. and 85 degs.

The reduction of benzole to a state of further purity, depends upon the property which it possesses and which distinguishes it from coal naphtha, and from all the other hydrocarbons contained in the naphtha, viz., that of becoming solid when exposed to a low temperature, and of melting again when pure at a temperature a little above that at which ice melts. The degree of cold requisite to solidify the fluid will vary inversely with the degree of purity which it has previously attained by distillation. If nearly pure it will solidify at 0 deg., if about half the fluid be benzole, and the rest the other hydrocarbons of the naphtha, which distil over with it, the benzole will crystallize out of the solution, when exposed to a temperature of 20 degs. And I may state that, generally, if the crude benzole obtained by once distilling the first runnings of the coal naphtha, or the whole light oil, or the rectified naphtha, as described in the first part of my invention, viz., from a boiler surmounted by a head surrounded with water, which is allowed to become heated to ebullition, be again rectified in a similar apparatus, and the first portion of the distillate equal to one-third the quantity placed in the retort (especially if the very first one-sixteenth portion be set aside separately as alliole, which does not solidify at 0 deg.), or if that portion which comes over while the temperature in the retort is rising from 80 degs. to 90 degs. be reserved as benzole, that portion so received on the second distillation will, if submitted to a temperature of —20 degrees, become in great part solid, depositing crystalline matter equal to at least half its bulk. By further rectification both of the mother liquor of the solid portion (that is, of that portion of the spirituous substance which is separated as fluid from the solid benzole after refrigeration), and also of the rest of the distillate on this second rectification, a further portion of spirituous substance may be obtained which will solidify at —20 degs. I now expose the benzole which has been prepared for refrigeration to a low temperature in a suitable vessel, and for the production of this low temperature I use, if it be necessary, a freezing mixture. When the benzole has been so congealed, I expose it to a powerful pressure, and the more powerful the pressure by which this separation is effected the purer will be the result, and the lower the temperature at which the operation of pressure is conducted, the larger will be the produce. The fluid pressed out is set aside, and after further rectification, if required, will yield another portion of solid matter by refrigeration.

The purification may be carried still further, either by again pressing at a temperature of 0 deg. the mass obtained by a first pressure, or by placing the mass in a funnel, and allowing it to melt slowly in the air, with the bulb of a thermometer immersed in the mass, reserving as pure that which remains solid when the temperature of the mass has risen to 0 deg. I call the substance so produced absolute benzole. It will be found to boil constantly

at 80 degs. or 81 degs. It will produce a state of intoxication if inhaled in the manner in which ether is used. It is an excellent substitute for ether, in many uses to which ether is applied, as for the solution of iodine, quinine, wax, and fatty and volatile oils. The next spirituous substance, or toluole, which when pure boils at about 110 deg., and which may be obtained in a state of partial purity by reserving the last portions which come over in the rectification of benzole, and the first which come over in the rectification of camphole, is purified by treatment with acids in the same manner as the benzole, but not by refrigeration. And I wish it to be understood, that by purified toluole, I do not mean a chemically pure hydrocarbon having a fixed boiling point, but I mean an oily or spirituous substance obtained from the coal naphtha, which will boil chiefly between 100 degs. and 130 degs. being so much of the naphtha as remains after separating on the one hand as much as possible of the spirituous substances that will yield a white flame with a current of air passed through them, and on the other hand as much as possible of the oily substances which will not take fire on the surface on the application of a lighted match, both being understood of the fluids at the ordinary temperature of the air.

Since all that applies to toluole as regards its purification, is also applicable to common naphtha, and to other bituminous and empyreumatic oils, such as petroleum, or native naphtha, the oil distilled from bituminous schist, &c., I will here state my method of purification as applied to coal naphtha, generally observing, however, that in the application of concentrated sulphuric acid to common coal naphtha, a certain proportion of oil is lost by the destruction of much of the cumole by the acid, I add to the naphtha, or toluole separated as above described, concentrated sulphuric acid in the proportion of about three quarters of a pound, and nitric acid or aquafortis in the proportion of about a quarter of a pound to a gallon of the naphtha or toluole, which has been previously carefully separated from water. I then agitate them well together in a suitable leaden or other vessel. The nitric acid need not be the strongest, that of specific gravity between 1.30 and 1.40 is suitable, and it need not be pure; the crude acid, known as nitrous acid, or the acid called single aquafortis, may be used.

I do not confine myself exactly to the proportions here given, or I use a mixture of nitric and hydrochloric acids, or nitromuriatic acid, or nitrate of potash or of soda, instead of nitric acid, in about the same proportions, with or without the addition of an equal proportion of bichromate of potash, or bichromate of potash without the nitrates; but if I use these salts instead of nitric acid, I prefer to use a rather larger proportion of sulphuric acid. Since the object is not to form definite chemical compounds, exact proportions are unnecessary; all that is requisite is to have

sufficient free sulphuric acid to dissolve the naphthaline, or a part of the naphthaline, in the naphtha, and not sufficient to dissolve much of the other hydrocarbons; to have sufficient free acid of any sort to dissolve all the alkaline oils (aniline, picoline, &c.) and to have enough of the oxidizing agents, sulphuric, nitric, or chromic acids, to convert at once all the coloring matter into new volatile products, and to have enough nitric acid to convert a small quantity of the naphtha into an aromatic oil, which leaves a slight fragrance in the naphtha when separated from it by subsequent distillation. After thorough agitation and subsidence, I withdraw the naphtha, and wash it thoroughly with a large quantity of water till all the acid is removed. It is advisable to separate the naphtha carefully from the acid before adding the water, otherwise certain compounds may be precipitated by the water from the sulphuric acid liquor, which may impair the purity of the oils. I then either agitate the naphtha with a solution of caustic lime, caustic soda, or caustic potash (preferring lime or soda to potash as being cheaper); and then either distil the oil with the alkaline fluid, or after removing it from the alkaline fluid in a still, to which fire is directly applied; or I rectify it by passing steam through it in the manner already known and in use; and when so distilling, I sometimes pass the vapor through a dry lime purifier, as hereafter described, when speaking of the purification of camphole. I then carefully separate the naphtha from water, and it is fit for use; or I sometimes allow it to stand, after agitation with chloride of calcium or chloride of lime, in vessels in which a small quantity of those substances has been placed, which removes the remainder of the water.

The toluole or naphtha so purified is applicable to the melting of varnishes, and to combustion in lamps, in which oil of turpentine or coal naphtha are usually burned, and also to burning in lamps when mixed with alcoholic or pyroxylic spirit; or to naphthalizing a current of heated air, so as to confer on it illuminating properties on being ignited.

The camphole, which is obtained by the rectifications of the last portions of the light oil, and the first portions of the heavy oils of coal tar, is purified in a different manner, since, firstly, it contains a large quantity of creosote and other acid substances, and secondly, a considerable portion of the hydrocarbon, which is required to be purified, is destroyed by treatment with concentrated nitric or sulphuric acids. And the method which I adopt to purify this oil is to digest it with a caustic alkaline lye, and to distil it so that its vapor may pass over lime, and to agitate it with hydrochloric acid, or with dilute nitric or sulphuric acids; and I prefer to treat it first with alkali for this purpose. In a boiler or retort with two apertures or necks, one of which is directly connected with the upper condenser hereinafter mentioned, and the other with the condenser of an ordinary still,

(which boiler I prefer to be of cast iron), I place the crude camphole with about a quarter its bulk of a solution in water of caustic potash or caustic soda of specific gravity about 1.150, or with a similar quantity of a solution of hydrate of lime in water, with an excess of fresh-slaked lime, or with dry caustic potash, or caustic soda, in the proportion of a quarter of a pound of the alkali to a gallon of the oil, or with caustic lime in rather larger proportions (the carbonates of soda and potash may be used, but they do not act so perfectly as the caustic alkalies or lime in the removal of the acid substances, and in the oxidation of the other impurities). The boiler or retort is surmounted with a vapor chamber, or head similar to that recommended for the rectification of benzole, it being so connected with one of the necks of the retort, that all the vapors condensed in it shall flow freely back into the retort. This head is kept surrounded with water as cold as possible, as the object of it is to condense all the vapors and return them to the retort; it may be connected by its other or upper opening with a still-worm to condense any vapors that may escape, or its other opening may be closed with a loaded safety valve. The oil and caustic lye being placed in the retort, the neck of the retort which is directly connected with the still-worm is closed, and that connected with the upper chamber is opened; fire is applied, and the aqueous solution is to be allowed to boil. The ebullition will continue for any length of time, if the condenser in the upper condenser be perfect, and even if a small quantity of vapor be allowed to escape condensation, the digestion will continue for a sufficient length of time. I allow this digestion to continue for five or six hours after ebullition has commenced. I then either lower the fire to stop ebullition, and draw off the watery solution through a pipe at the bottom of the boiler, and then close the neck connected with the upper condenser, and open the other neck of the retort which is directly connected with the still-worm, and then distil the oil over; or I change the outlet in the same way, and distil without first drawing off the lye. In the latter case, oil and water will come over together at first, and the temperature in the retort will not rise far above 100 degs. or 110 degs. till nearly all the water and a large quantity of the oil has come over; but if the water be drawn off, the temperature in the retort will soon rise rapidly to 140 degs. or 150 degs. before any fluid distils. I then sometimes set aside the first portion that distils over so long as samples taken in a small open vessel catch fire on the surface on the application of a lighted match, and I prefer to receive as camphole that which comes over subsequently till the temperature in the retort reaches 190 degs. The residue is distilled over, distillation being stopped when the temperature in the retort reaches about 300 degs., if it should rise so high before distillation ceases, and is mixed with the dead oil in the same stage of purification, unless

this residual distillate contain much naphthaline, in which case it will solidify partially or entirely, and the solid part is rejected and the fluid part only of this residual distillate is added to the dead oil. The camphole, after this distillation, is now agitated either with common hydrochloric acid, or with dilute, sulphuric, or nitric acid, formed by mixing the strong acids of commerce with about six times their bulk in water. This agitation is continued for a convenient length of time, and may be done in an open vessel with a stirrer. Having allowed the fluids to separate, I draw off the acid, and then I sometimes repeat the agitation with a further quantity of dilute acid with the addition of some chloride of lime in the proportion of a quarter of a pound of chloride of lime to a gallon of the acid, but this may be omitted. The oil is drawn off and well washed with water, from which it is separated, and then rectified. It may be rectified by passing steam through it, or by distilling from a retort to which fire is directly applied, but in either case it is convenient to place between the retort and the condenser a vessel similar to the dry lime purifiers used for purifying coal gas, in which lime is placed on plates or gratings in a chamber having only two openings, so that the vapors pass over the lime, and I prefer to have this lime purifier of such size that it may contain lime conveniently spread in the quantity of about half a pound of lime, more or less, to a gallon of the oil placed in the retort, but a smaller vessel may be used. This vessel is so arranged that the vapor of the oil, or water and oil, as it leaves the retort, passes over the lime which deprives it of dry acid remaining in it, and then passing into the condenser is reduced to the fluid form. But I prefer to rectify it in a retort over fire directly applied without the presence of water or steam, and to use a thermometer inserted in the retort, and to cease receiving as camphole when the temperature in the retort reaches 190 degs. By this means I obtain the oil colorless, and it should be of specific gravity, .890 or .900, or if the distillation be not continued so far, the specific gravity may be so low as .870. Concentrated sulphuric and nitric acid, separately or mixed, may be used in the purification of camphole; but I prefer not to use such acids, as a considerable loss of hydrocarbon is thereby sustained, and the use of concentrated nitric acid sometimes confers a yellow color on the oil which it does not lose on rectification. I sometimes repeat this treatment with alkali and acid once or oftener. Camphole so purified is applicable, either alone or mixed with the common naphtha of commerce, or mixed with some of the oils having lower boiling points separated in my processes, or with the pyroxylic spirit for burning in lamps. It is also useful as a substitute for oil of turpentine in making varnishes.

For the purification of the dead oil I adopt the same method of digesting with an alkali as that which I have described for

camphole, but I prefer to use a stronger lye and in larger proportions, and to continue the digestion for a longer time before I change the outlet and commence distillation, since the dead oil contains a larger quantity of acid substances. The same description of apparatus and the same sorts of alkali are applicable to the dead oil as to the camphole, but caustic alkalies are much to be preferred to carbonates. And in rectifying the dead oil from which the camphole has been previously separated by distillation, which is that which I prefer to treat in this manner, though the method is equally applicable to dead oil from which the camphole has not been removed after digestion with the alkali. If the lye be not drawn off, very little oil will be carried over with the water which distils off first, and whether the lye be or be not drawn off, I prefer to receive separately all the oil which comes over, before the temperature in the retort reaches 200 degs., and if there be little naphthaline present, I add this oil to the camphole of the corresponding degree of purity. If there be much naphthaline present, I reject so much of that part of the distillate from the dead oil as solidifies in the cold, which will be the case in some instances while the temperature is rising from 210 degs. to 220 degs., or even higher. And the quantity which it will be convenient to reject may be ascertained by observing whether a thin film of the distillate received on a cold surface solidifies, when the temperature in the retort is above 210 degs., when it ceases to solidify; on being so examined I commence to receive the mortuole for purification. If none solidify on cooling, I receive all the distillate above 200 degs. together, till the temperature in the retort reaches 280 degs. or 290 degs., I reject what comes over above as containing too much paranaphthaline. And, instead of treating the oil with dilute acid, I treat the dead oil, after distilling from the caustic lye, with oil of vitriol, in the proportion of one pound of oil of vitriol to one gallon of oil, and with or without the addition of a small quantity of nitric acid; I agitate the acid with the oil in a suitable vessel for one or two hours, and I prefer to allow the oil to stand with the acid for two or three days, and to repeat the agitation occasionally. I then draw off the oil from the acid, after having allowed it to settle. Finally I distil it through a dry lime purifier, as described for the purification of camphole. The oil should be collected in this rectification between the temperature of 220 degs. and 280 degs. This oil will be of a pale yellow, or almost colorless. I sometimes repeat this treatment of the mortuole with acids and alkali, once or oftener.

It is convenient sometimes further to purify the mortuole, camphole, and other oils, and spirituous substances, by filtering them through finely divided carbon, for which purpose I prefer animal charcoal or lampblack, which has been digested for a short time in oil of vitriol, or boiled in a solution of carbonate of potash, and then dried and heated to redness in a closed vessel

recently before use. And the filtration may be conveniently conducted by placing the oil in the filtering apparatus, over a vessel or receiver, into which the oil will be forced through the filterer by the pressure of the air, when the air is exhausted from the receiver. By further treatment with caustic alkali or lime, and with sulphuric acid, and by subsequent rectification, the mortuole may be obtained quite colorless. The oil so obtained is applicable to many of the purposes to which oil of turpentine is applied, and also to many of the purposes to which fixed oils are applicable, and it is applicable either alone or mixed with the more volatile hydrocarbons to burning in naphtha vapor pressure lamps, and when mixed with pyroxylic spirit in suitable proportions, to burning in lamps in which oil of turpentine or the fixed oils are burned.

What I here claim in respect to this second part of my invention, is the purification of the spirituous substances and oils which I manufacture from coal-tar, by treatment with chemical agents, according to principles laid down, depending on the nature of the spirituous substance and oils aforesaid, and of the impurities desired to be removed.

I also claim the use of nitric or nitrous acid, of nitro-muriatic acid, and of chromic acid, and the salts of those acids in the purification of empyreumatic and bituminous volatile oils, and the purification of certain of the oils manufactured from coal-tar by digestion with alkalies in the manner above described, and by distilling them so that their vapor is passed over lime, in the manner above described, and the purification of a spirituous substance obtained from coal-tar by congelation and pressure, which substance so purified I call absolute benzole.

Art. II.—GOLD ORES AND THEIR WORKING.

As the attention of those who are engaged in the working of gold ores, appears at the present time, to be more particularly directed to the mechanical appliances, by which the separation of the gold from the gangue-stone can be produced, than to the various descriptions of ore which are presented to their operations; I have thought it the most advisable plan to follow, in these papers now submitted to the public, to give a brief description of the most common methods of crushing and amalgamating now in vogue, and also to show the principles which actuate such manipulations, and to endeavor to point out such adaptations of those principles, as appear to me to be the most likely to aid in obtaining such results, as the labors of those interested are endeavoring to produce.

Perhaps the most correct method of procedure would be, to first describe the varieties of gold ores, their usual position, their characteristics, and attendant phenomena, together with their chemical constituents, and some observations upon their formation, such as may be drawn from actual observation and close examination.

But practical utility being my aim, and as the various ores are to a great extent well understood by those who are working them, I shall defer this part of the subject until after the appliances have been fully treated upon, and then take it up, in the hope of presenting the whole subject to the miner and general reader, in a plain and simple manner, which, if it does not present any new truths, will at least bring together, in a collated form, many of those already known.

Leaving, therefore, the description of mining and of the ores, I would, before entering upon that of the varied machinery, state a few important facts and principles, that during the working of the ore must never be lost sight of.

1st. Regularity and uniformity of "feeding," or supplying the machinery with ore, must be rigidly observed.

If the ore at any portion of the work is crowded into the machinery, without a due regard to the quantity that is to be regularly supplied to it, it follows that either the crushing or the amalgamation must be proportionably imperfect. If, in the crushing department, the ore will be passed through the crusher, not reduced to that extreme state of disintegration, which is requisite to liberate the minute particles of gold contained in it. This point has been fully borne out in my own experience, and corroborated by that of all practical operators with whom I have corresponded or conversed upon the subject. Numerous authorities to substantiate this rule could be quoted; but that of Hocheder in his valuable experiments, is directly to the point. He found that regularity was essentially requisite. That care was necessary that the ore was not passed over the works too coarsely ground; as when such was the case, much of the gold was washed away in the grains of the ore. He says, "The quantity of coarse stamped jacotinga [ore] which is rolling over the skins, into the river, attracted my attention, and I separated a portion of it from the fine stamped jacotinga, by means of a sieve, and caused the coarse grains to be pounded to a fine state, which showed, by washing, very good samples of gold. But the coarse grains with their contents are lost." In the amalgamating department the quantity of ore, if too great, will prevent that direct contact of the gold and mercury, so necessary to produce the desired amalgam, and consequently much of the gold will be lost by being washed away. If, on the other hand, the quantity of ore be deficient, valuable time will be sacrificed and an undue wear of machinery will be produced. The gold, in this case,

will, much of it, be washed away by the quantity of water being disproportioned to the amount of ore. The flouring of the mercury will also be greatly increased, entailing an additional loss, if the supply of ore is insufficient. As I have already brought Hocheder forward as a witness, with his experiments, I will avail myself of his able scrutiny once more. He found that from forty to fifty per cent. of the gold was lost by being stamped to too fine a powder; as by this means "the smallest particles of gold, stamped nearly to the state of slime, and which lose the action of specific gravity, will alone amount to from twenty to twenty-five per cent.; which is never to be gained by any means of separation founded on mechanical principles."

2d. The "feeding" must be slowly performed.

Gamboa, on "amalgamation," states to this purport, in regard to slow manipulations.—In Guanaxuato, where the matrix is hard, and the ore finely disseminated through it, and more pains are taken in this operation, it is not usual to allow the charge to exceed six or seven quintals; to grind which, four and twenty hours are employed, and sometimes, if the ore be rich, as much as eight and forty hours.

A great advantage is derived from reducing the ore to the fine powder thus obtained, as appears from the analysis of the residue of the amalgamating process; and that it would be highly advantageous to the other districts to follow the example of Guanaxuato. Hocheder also insists upon slowly operating the ores. My own experience was to this effect; I was using a new crusher, "Bullock's Quartz Crusher," and supposed that all that was necessary was to crush as fast as possible, and rush the slime through the amalgamating apparatus. I crushed the quartz rock at the rate of from two to two and a half tons per hour, but I obtained no gold. I supposed that the large amount of mercury used was not "charged," as the point of saturation it must reach before it will yield amalgam, is termed, and worked on until I was sure that it was so; I then continued to pass the slime through as rapidly as ever; but obtained no gold. This was to me a mystery; assays proved the ore to be rich; panning showed it to be so; particles of gold were visible in much of the ore, but when it was operated upon the precious metal disappeared. I then began to work more slowly, and found reason to be encouraged; and continued the slow movement until I had brought down the crushing action to the capacity of the amalgamating force employed, and the result of the last experiment tried upon one ton of ore, which gave fifty-six dwts. of amalgam, proved that the work must be slowly performed.

3d. A state of rest must be allowed to the ore, as frequently as can be done, during the manipulation.

4th. While in that state of rest, a continued showering of water-drops should be maintained from a moderate elevation,

upon the surface of the water in the tanks containing the slime.

By allowing the slime when washed from the crusher to fall into tanks of sufficient capacity to retain one or two days' work, it will be found that this state of rest will facilitate the deposit of the particles of gold, and prevent much of the loss, which results from allowing the water to pass through the whole process, in one continuous stream, thereby carrying away much of the gold suspended in it before it has time to subside to the bottom of the current.

The fact is well known that gold leaf is easily wafted away by a very light current of air; if the gold can thus be suspended in so light a fluid as the atmosphere, it certainly can easily be washed away in a current of the more dense fluid, water, and more particularly, if that water should be rendered still less fluid, by the intermixture of large proportions of earthy materials. The tendency of gold, when in minute particles, to float upon the surface of water, may very easily be shown, by finely dividing a small portion of gold left upon a smooth card, and gently blowing the particles from the card upon the surface of water; or by filing a small quantity of gold over the surface of water; or by placing a small quantity of water in a basin, and so inclining it that only a portion of the bottom shall be covered by the water; then, allowing the filings to fall upon the uncovered portion, and so turning the basin that the water shall gently flow over that portion upon which the filings have fallen. These simple experiments will readily prove that gold will float away upon the water, unless the utmost care is used to prevent such an occurrence. By freely wetting the fingers, or, better still, a whis -broom, and sprinkling the water drops off upon the water upon which the gold is floating, the advantage of this vertical agitation of the water will be instantly apparent.

It is in this state of rest that the fine particles, mentioned by Hocheder, as quoted under the first rule, as "never to be gained by any means of separation founded on mechanical principles," are, most of them, at least, to be saved.

5th. In all horizontal rotary motion the discharge of slime should be from the centre.

When the slimes enter machinery of this character, their specific gravity causes them to fall at once to the bottom; there the centrifugal force of the rotary motion, either of the bowls themselves, or of the appliances contained in them, forces them to the circumference, and produces an under current in the same direction, and a tendency for the slime to accumulate near to the outer rim of the aparatus. The under-current is necessarily counterpoised by an upper current from the exterior to the centre. Nothing but the lightest particles can float along this gentle current across the apparatus, without sinking beneath the sur-

face, before they pass the entire distance. Consequently only the lightest sands can pass away. By this plan little or no loss can ensue from the floured mercury, as it must sink and be recombined with the fluid metal.

6th. Fresh, clean water should be introduced at each stage of the amalgamation.

The object of this arrangement is so obvious that it requires but brief explanation. After each state of rest, the slime will have to be removed by hand from the tanks, and fed into the machinery; it here becomes necessary that the water should be as free as possible from any admixture of foreign matter, to allow the specific gravity of even the most minute particles of gold to have its full effect; which it could not do were the same water, as had already been once used, to be again operated with.

Considering the ores then as already at hand for operating upon, the first step in the process will be to reduce them to that state of division by which the gold can be most easily separated from the accompanying rock; this is accomplished by

CRUSHING.

The crushing of gold ores has been endeavored to be effected in as many various ways as there were minds to plan the mechanical arrangement. It has appeared as if every man that ever heard of a gold mine, immediately believed himself to be the only person capable of constructing the requisite machinery for the successful operation of the ore. Men have placed themselves before their tables, and spreading out their drawing instruments, have elaborated upon the smooth surface of the Bristol-board or their drawing-paper, most beautiful specimens of human ingenuity, developing in the ablest manner the highest perfection of mechanical principles, and producing ornamental delineations of gold-working appliances, which, when patented, constructed, *purchased*, transported and placed upon the mines, were found worthless, futile, and useless. They lost sight of the important fact, that some experience was a necessary ingredient to combine with their calculations; they forgot the homely adage that "Necessity is the mother of invention," and consequently have produced works that are now scattered broadcast over the mining districts, which serve only as monuments of folly and ill-directed labor. To crush gold ores, which usually are of siliceous formation, requires heavy, ponderous machinery, the mere weight of which, passing over the quartzose rock, reduces it to a powder. No elaborate combination is involved in this requirement. The machinery must be massive, simple, and of such construction, that the portions most liable to wear away by the friction of the ore, can be easily replaced; too strong in its parts to break under the powerful pressure to which it is subject, and made of such permanent material that no exposure to the changes of cli-

mate or weather can sensibly affect it. It should be sufficiently capable to perform all the work that may be required of it to do; that is, if twenty, thirty, or even fifty tons of ore per each twenty-four hours, can be raised from a mine, the crusher should be able to fully pulverize it. The machinery should always be sufficient to control the mine. If not adequate for this purpose an accumulation of ore must ensue, or a retarding of the successful development must occur. It is owing to the failure of so many inefficient machines, that much of the doubt and discredit now attached to mining operations has arisen. It is seldom that an actual practical test has been made of the machines before they are offered for sale; the whole merit which they are said to possess is purely theoretical. The only way to prove any machine is not upon a ton or two of ore under the most favorable circumstances of working, but to place it upon the mine, and with the work before it, see if it can be made to execute it. No other test should ever be accepted. Too often the merits of the machines have been extolled with all the force that language and imagination could command; and could they have accomplished a moiety of the "immense advantages," which were claimed for each, as its own peculiar value, they would almost have gathered the golden grains from a barren sand, or have created them from the ingredients of a solid rock, utterly devoid of metallic presence. The uninitiated have credited these tales of marvel, and have eagerly paid their good dollars for bad stock. And now, without stopping to discriminate between their own folly connected with illegitimate mining, and sound common sense, and true economical mining, they class all mineral operations under the censorious title of "humbug!" From the feeling thus engendered and promulgated, capital which else would be invested in mining properties, seeks other channels, to the detriment of the true mining interest of the country. There is no branch of industry, from the advancement of which the capitalist can derive more pecuniary emoluments than from that of mining; legitimate, economical, well-directed mining. From the little knowledge which I have been able to gather of the mineral resources of our country, I can foresee that ere the close of the next half century, the mining interest of the United States is destined to be the most important resource of national wealth. It is therefore with emotions of pain that I see these worthless specimens of machinery palmed off upon a class of men, who, with a laudable ambition of availing themselves of mechanical aid in the prosecution of their labors, and by their very eagerness to progress, are easily deceived by the plausible and falsely termed merits of the invention. Every such machine that is placed upon a mining location is an additional clog and hinderance to the prosperity of that mine individually, and to the mineral welfare of the entire country. How, ask the mining managers, are we

to know whether a machine can be made to fulfil the promised results? We hear it strongly attested to, on the score of merit, and tied down as we are with our local duties, we cannot make the personal examinations we would desire to do, and must take the risk of relying upon the judgment of less practical friends." If the mining men would but adopt as an universal rule, that they would not purchase any machine until it had been placed upon their mine and proved by actual results to be all that its projectors had promised, they would escape the wasteful expenditure of thousands of dollars, that might better be devoted to sinking shafts, and to driving galleries upon the veins in their possession. Any company, or any individual, that entertains full confidence in their appliance, will not hesitate, upon a valid contract from the mine-holders, to purchase the machine if it will perform a stipulated amount of work, to place it upon the property, and give it a fair and impartial trial. If such a course should be adopted by any company, their own interest will prevent them from over-estimating the efficiency of their machine, as such exaggeration would render certain a failure of their contract; they would rather under-estimate its ability to work, that there might not ensue too great a risk of failure in performance.

Upon the property which has been under my management for the past year there is in use a crushing machine which was placed here under the above-named terms of contract, and which not only performs all that its proprietors claimed for it as able to do, but is capable of turning out at least twenty-five per cent. more work. It is a ponderous and simple machine, easily kept in running condition, and will readily crush from two to three tons of quartz per hour. We run it with an engine of about thirty horses' power, which also carries the amalgamating force of eight arrastres and thirty-four stirring bowls. I merely allude to the facts, and deem it but an act of simple justice to an ingenious inventor, to state, that "*Bullock's Quartz Crusher*" is the best adapted machine for reducing the quartzose ores to the required fineness in the shortest time of any mechanical appliance that has fallen under my observation.

It is my fondest hope and strongest desire to see the mineral value of our country correctly appreciated; and though but an humble laborer in the vast field, I am anxious to perform my portion of the great work that is to be accomplished.

The most common method of reducing the ores to a powdered state is by means of the

CHILIAN MILL.

It is constructed by having two large and heavy stone wheels made to revolve upon a solid stone bed. Around this bed a wood work of about twelve inches in height is placed, forming a large tub, of which the stone bed constitutes the bottom. Into

this basin the ore is thrown by small portions from time to time, and is crushed by the weight of the wheels rolling over it. The stone bed is usually about six feet in diameter, and from ten to eighteen inches thick. The wheels, or "runners," as they are called, are of about the same dimensions, and are kept in motion by suitable geering connected to an upright shaft, which is "stepped" upon the centre of the bed, and makes from six to ten revolutions per minute. The axles upon which the runners revolve are placed within a strong framework, which surrounds instead of being attached to the shaft; thus allowing sufficient vertical play to the runners while passing over the fragments of ore. The average quantity of ore crushed by one of these mills in twenty-four hours, is about forty bushels, or two tons. A stream of water enters over the rim upon one side of the tub, and is discharged over the rim on the opposite side. This stream should be sufficient in quantity to hold the comminuted sands in suspension, and allow them to be floated off in a thin slime. If the quantity of water is insufficient the sands will pass away in so thick or muddy a condition that the specific gravity of the gold will be of no avail, and it will be carried off by mechanical suspension. If too heavy a head of water is applied the sands would be washed away, either in too coarse a state for the gold to be liberated, or too rapidly for it to be saved. A great advantage will be derived from the occasional addition of a small quantity of quicksilver to the sands in the mill. It will be found, if a fair trial is instituted, that more amalgam will be obtained from the same quantity of quicksilver applied at intervals than would be gained by adding it at one time. A positive advantage will be obtained by having the Chilian Mill so constructed that its discharge shall be *through the centre.* In this mill particularly, a *slow and uniform* rate of operation must be maintained; the work *cannot be hurried* without entailing a loss of gold.

In Mexico and South America the Chilian Mill is used dry. In the United States it is always used with water.

It has been suggested that greatly increased beneficial results will follow the occasional stoppage of the flow of water in the Chilian Mill operation, particularly while crushing a bed of ore. This point appears to me so feasible that I should consider it well worthy the attention of all interested.

I find that Mr. Boussingault tried at the Columbian Mines the same principle, but in the arrastre. "The mineral was put into the arrastre, with a sufficient quantity of water to give it the consistency of a thin paste, * * * * and was then ground for thirty-two hours, * * * * the amalgam was obtained with great facility." Marmato, August 12, 18—.

It will be found advantageous to carry out the principle of rest, by having tanks, into which the Chilian Mill will discharge its sands or slime; it will be well to have three tanks so ar-

ranged that each one will be of ample dimensions to hold from one to two days' work of the mill, and the amalgamation should not proceed until the first and second tanks are filled; then the sands should be removed from the first tank, while the third is being filled from the Chilian; and from the second while the first is refilling; by this arrangement from two to four days' rest will be allowed to all the sands.

The addition of common salt occasionally while the tanks are filling up, will be useful, from its effect to increase the oxidation of the iron usually contained in the ore. By means of a perforated plate, similar to that used in a shower bath, a small sprinkling of water can be constantly maintained over the surface of these tanks.

Next to the Chilian Mill the most common method of crushing is effected by the use of the

STAMPS.

Easy and simple in their construction, and in the application of power to their movements, it is not surprising that they should be found at work upon so many mining properties. They are formed usually of six pieces of timber from four to six inches square, and about twelve feet long, armed with such a heavy iron head, and maintained in a vertical position, by a simple framework, which allows of their moving freely vertically. The motion is communicated by cams on a revolving horizontal shaft, which, lifting the stamps, alternately, to a slight elevation, allows them to fall, and, by their weight, to crush the ore placed in a trough beneath them. The size to which the ore is reduced is regulated by a grating inserted in the front of the trough, through which the slime is washed by a small stream of water allowed to follow under the stamps for that purpose. The facility with which they can be made is not their only recommendation, for on the score of efficiency they deservedly maintain a high reputation. On the same kind of ore they will do as much execution as the Chilian Mill, but they cannot, like it, be used both for crushing and amalgamating.

Upon ores in which the gold is disseminated in a state of extreme division the stamps will be found to entail a loss which would not arise under a crushing process; still, I think, if the system of "rest" should be allowed immediately after the stamp work, much of the loss of minute gold would be prevented. On ores containing particles of coarse gold, if the grate is set coarse, the stamps will prove to be a valuable method of reducing the rock to sand. Stamps are used with water or without it, as suits the views or fancy of those using them. There is a considerable difference of opinion among those who use the stamps, as to which branch, the wet or dry, belongs the superiority. I am inclined to favor the wet process for all kinds of ore. I believe

less gold is lost by the wet method than by the dry; and much testimony can be induced in favor of its greater economy on the score of cost. The following extract from Mr. Harkort's Report to the Bolanos Association in 1830, is decisive on this point;—"The costs of a *dry* stamp work, by the Mexican process, on 1,000 quintals is $124, while the cost of *wet* (German) stamp work on 1,500 or 2,000 quintals weekly, at the highest would be but $24, saving $100 on each torta, and the loss by amalgamation less, as the flour become much finer than by *dry* stamping."

Perhaps it would not be out of place at this point to present a brief view of the Mexican treatment of ores. The ores when taken from the mine are broken in small fragments, and separated as well as can readily be done, from the gangue-stone. They are then passed through the stamps; usually the dry stamps. Then they are worked in the arrastre; afterward gathered into flattened circular heaps, called "tortas," on a close pavement, and thoroughly intermixed with common salt, the tendency of which is to assist in the decomposition of the iron pyrites, by forming a muriate of iron. Quicksilver is freely sprinkled upon and incorporated into the mass; a second and a third quantity of quicksilver is added until there is enough to take up the gold contained in the slime of the "torta." The slime is then washed in a vat, and kept constantly agitated, by which means the lighter impurity or earthy matter, is floated away by the discharge trough at the surface, and the amalgam remains at the bottom of the vat, from which it is easily gathered after drawing off the water. From the above brief outline it will be perceived that the Mexican process involves a continued succession of "rests" for the ores; allowing time for the gold to subside, and time for the amalgamation to proceed.

Constant care and attention are necessary upon the part of the stamp-tender to see that the supply of ore is regular both as to time and quantity. If, through a desire to gain for himself some extra moments of leisure, the stamp-feeder should throw under the stamps an over supply of ore, the water will be so thickened with the mud and sand that the gold will not fall through it, but be carried off by being held in suspension in the muddy mixture. If, through neglect of duty, he omits to furnish the necessary quantity of ore to the stamps, the too rapid flow of the clear water will carry away the fine particles of gold by its greater force.

As in the case of the Chilian Mill, I would repeat here, even at the risk of being charged with tautology, that the work *cannot be hurried;* that it *must be slow and regular*, and that any deviation from this course *will entail a corresponding loss of gold.*

S. P. I.

To be continued.)

ART. III.—A GEOLOGICAL RECONNOISSANCE OF THE STATE OF TENNESSEE.

WE are pleased to notice another State Report, another of the finger-marks of our age. This Reconnoissance is, as the title-page announces, "*The First Biennial Report presented to the Thirty-first General Assembly of Tennessee, December*, 1855, *by James M. Safford, State Geologist, Professor of Natural Science in Cumberland University, Lebanon, Tenn., &c.*"

Tennessee was early in the field with her State Exploration, having been preceded only by North Carolina, South Carolina, and Massachusetts, of which latter State Tennessee was only some two or three years posterior. In 1839 Professor Troost published a Geological map of the State, and up to 1845 had made some seven or eight annual reports; some of the later ones, however, being merely pamphlets, as might have been expected from a Legislature which, from the meanest parsimony, tolerated rather than encouraged the exploration of her own resources.

In elucidating the geology of the State, Prof. Safford has adopted for inceptive operations a Reconnoissance, or General Survey of the whole State. This mode of commencing the survey was the result mainly of a suggestive, or, perhaps, constraining public sentiment, and measurably of a conviction of its utility and adaptability to the popular apprehension.

This plan may be a good one, and certainly is so, prima facie, but is it a reliable one? Is it not too subject to the uncertainties of superficial explorations, of comparatively new ground; and until detailed examinations have detected all the analyses of older and better known fields of geological research, is it not too liable to changes and differences of allocation? We would not except to it here, however, but suggest the question of its expediency as one yet to be decided by competent authority. The *utilities* of the plan in the present survey have certainly been many, and of great practical value.

It has presented, in a comprehensive style, by a finely furnished and scientific mind, an outline of the geognosy and mineral values of the State. It has grouped the common characteristics of distinct regions, designated points of special interest for detailed examinations, and cleared the way for future economic explorations. As Prof. Safford well says, "*Geological formations are the great storehouses of mineral treasures*," and the determination of the position, extent and mineral contents of these great repositories was a leading object in the reconnoissance. Dr. Troost, who had acted as State Geologist before Prof. Safford, did much to open the way for subsequent explorations, and Prof. Safford says, "that Dr. Troost's researches, although *he never had the means to give them that scope and utility* desirable, have never-

theless accomplished much towards this end, and one could easily point out how his labors *have already paid the State in actual capital, threefold more than they cost it.*"

Here we have another instance of State parsimony—the incubus imposed by legislative ignorance, upon the very elements of the State's power and force. Prof. Safford says, "we offer no apology for any defects that may be detected, our task has been an arduous one, *and the means placed at our disposal for prosecuting it very limited.* We have been *compelled to work without assistance*, except where it has been *gratuitously afforded us.*" And, with the modesty of true science, he ventures to suggest, "with reference to the future, that it is *very desirable*, that at least a *small appropriation* should be made to enable us to employ some one to assist and accompany us in our excursions. We shall, however, in any event, though it may be under difficulties, faithfully carry on the survey as far as the means given will justify." In this extract from Prof. Safford's preface to his report, we have the whole development of the antagonisms between the extremest modesty of true science and its kindred influences, and the narrow, contracted views of a great State Legislature. It does seem as if some Legislatures, when engaged on the subject of State surveys, or educational matters, conscientiously surrender all pretensions to common sense and the ability to apprehend the sources of the commonest values, and with a firm determination to appreciate no values except it may be those that make and build up some political shamble, it resolves to distribute State patronage among favorite partisans, and sympathizing political plunderers only. Tennessee has really carried the prize for parsimony, and among all her Western sisters, may inscribe on her flag, "*I am the richest in natural resources, and the meanest in the payment of talent to develope those resources.*" She is the very incorporated conscience of parsimonious profundity.

Let us present an impersonation of the respective parties to this survey. First, we see a lofty figure whose feet are of iron, whose legs are of coal, body of the elements of gold, and whose head is made of unknown material, for it wears a mask. With the proud assumption of conscious power it beckons to its presence another figure quietly passing by in the shade, a figure of beautiful proportions distinguished by no predominant feature, yet beautifully symmetrical and harmonious in all its parts; its composition most elaborate from study, and although not made up in any one member or part of any particularly valuable or precious metal, yet the elements of the most precious values appear in subdued and harmonious proportions on every part of the system. A mosaic where the general effect was produced by the perfect adjustability and concinnity of each piece in detail. The emanations from the figure were like moss on the bucket, speaking of fertility, or the bloom on the grape, telling of maturity; it imparted some of its own riches to kind touches, and

by a sort of magnetic influence discovered and assimilated with itself, consentaneous elements of wealth and beauty and harmony, no matter where or how deeply buried from common sight. Intuitively comprehending the wants of the figure in mask, it most cheerfully, and with its natural love for analytical and inductive beauties (for its name was "Science"), submitted to its dictation to explore and survey the country where the masked figure dwelt. The masked figure was of Borbdignagian proportions, and undertook to direct by its *largest* finger the points or places of greatest importance, forgetful that science, from its very elemental composition and atomic sympathy, instinctively, like the hound upon the trail, was most capable of reaching the best point first, and in the least difficult way. But, like all figures ashamed to show their faces, and that wear masks, its pathways were (to it) strewed with stumbling-blocks of lofty mountains, numerous rivers, or crooked and unbridged streams. Some of the most valuable elements of prosperity and success lay on the very surface, or clogged up the pathways on the country of the lofty figure: but to the figure all invisible—because of the mask which limited the field of vision. Science, on hopeful wings, thinks it may get over the obstacles, and attempts the exploration with the very reasonable and common sense notion that the masked figure will, at least, furnish a companion on the lonely exploration, at least, to hold up the telescope of observation, or jot in a note-book what science may note while holding the telescope. The crossing of perilous streams, scaling mountains, piercing caverns, threading lonely valleys, scarfing mountain-sides, unearthing out-crops, digging and delving into the bowels of mother earth, co-operating in analyzing the contents of those bowels; all these and many other items of labor, toil, and wearisome responsibility might suggest the necessity of an assistant or helping hand. But no, the mask, significant of some disreputable emotion, obscured alike the light of common sense, common justice, and the appreciation of unquestioned values. The mask, that above all others (especially when matters of science or education are to be seen through it) obscures the vision, produces stolidity and an inability to realize the most palpable objects of value; this mask, we say, is *parsimony*, a feature in a State's character as reprehensible as its opposite quality—*extravagance*.

Unaided and alone (except when individual hospitality and appreciation of intellectual worth lent a helping hand) we find Prof. Safford plodding his devious way amid the stony records of the past, disturbed by dislocations, cramped up by plications and foldings, or undergoing a mental decortication, as he beholds the denudations and drifts around him; but no sympathizing or helping hand is near—*he is every thing*—the first and the last, principal and stake-driver—observer and chain-bearer—and why?

because the great State of Tennessee wishes to save five or ten dollars a day—the pay of a few assistants.

We wish to be understood in this matter. We have in former numbers animadverted upon this parsimony of a great sovereign State which will squander thousands upon political profligacy and begrudge a pittance—the smallest livelihood—to the science, the learning, the talent, which elucidates and eliminates the most valuable and important elements of that State's prosperity.

And while we reprehend parsimony, we shall always and with equal earnestness denounce extravagance in expenditures for such purposes, and in a future number shall give an exhibition of wicked wastefulness that will tell at least in *one quarter*. Our mining habits and cross-cuttings lead us in contact with all sorts of developments, and so long as we can hold a mining hammer we shall hammer away at all abnormal formations that protrude themselves in the paths of true science and practical knowledge, we care not whether the formation is that of a State or of stone.

The natural formations of Tennessee (unlike her political) are rich and varied, and resolvable from their topography and mineral constituents into seven divisions, and which singularly enough determine the three great political divisions of the State into West, Middle, and East Tennessee. The Unaka, or Eastern outlying division, comprises the group of wild mountain ridges flanking the base of the great Appalachian system and marks the line of demarcation of North Carolina. Many of these ridges are covered with open woods, affording unobstructed passage to the traveller for miles and the finest pasturage grounds. Some, again, are entirely bald and locally termed "*Balds*," attaining in some points an elevation of 6,000 feet.

Next in order moving westward is the valley of East Tennessee, consisting of a series of *small troughs* and narrow straight parallel ridges, and very forcibly impressing the traveller with the notion that when he is crossing them from south-east to the north-west, that he is in a rolling country of "wave on wave succeeding."

Next in order is the *Cumberland Table-land*, comprising the Cumberland Mountains, and is in reality a table-land with well-defined rocky escarpments, and its sandstone top would furnish a noble highway from Kentucky to Alabama.

The Highland River of Middle Tennessee, [encircling] the Central Limestone Basin, the slopes of West Tennessee, and the Western outlier, the Mississippi Bottoms, make up the seven divisions. A particular analysis of each of these divisions requires more space than we can spare, but Prof. Safford has very neatly summed up the sketch: "Thus ends our brief sketch of the physical divisions of Tennessee. Mark the contrasts they afford! How unlike are the "Balds" of the *Unaka*, and the

Bottoms of the Mississippi; the *fluted* valley of the East, and the river-veined slope of the West; the wooded plains of the Table-land, and the rich rolling fields of our Central Basin. Surely there is no lack of marked variety in favored Tennessee."

Of the mineral wealth we may enumerate almost every element essential to the economics of American life. Iron ores, found under the most favorable associations, abound in the Limonite, Hematite, Dyestone, and Magnetic ores, scattered in inexhaustible profuseness.

Copper ore is found in Polk County, in the Unaka division, and when first found was supposed to be gold, but when ascertained to be *only red copper ore was considered of no account.* The sulphuret of lead (galena), carbonate of lead (cerusite), sulphuret of zinc (blende or black jack), carbonate and silicate of zinc (calamine), are all found in the State, but as yet little worked *or valued.* The sulphuret of silver has been found in the Cumberland mountains, but judging by the amount passing between the Legislature and State Geologist, we should think it a *scarce article*, and not easily *parted.*

The portion of the great Appalachian coal field is found underlying the Cumberland table-land before alluded to, and covers about 4,400 square miles. The varieties of coal are numerous, but most semi-bituminous and dry burning. Nearest the seat of greatest disturbance, (the eastern escarpment of the table-land,) the coals exhibit a spumose structure, and become more laminate towards the central and western portions of the track.

Tennessee has her marbles, and of beautiful texture, variety and color; specimens of some will be introduced in the new extension of the National Capitol. Green sand, marl, salt, nitre, alum, epsom salts, and peroxide of manganese, are found. "We have hundreds of *caves* and '*rockhouses*' in Tennessee, especially along the limestone slopes and in the gorges of the Cumberland table-land, which afford materials—nitrous earth—for the manufacture of nitre."

The efficient principle of the nitrous matter in the earth of these caves has undoubtedly been derived from the decomposition of animal matter brought in by wild animals during past ages, and as nitric acid has united with the lime and potash of the earth.

Hydraulic limestone, burrstone, roofing-slate and flagstones, are among the other useful products developed or classified by Prof. Safford's industry.

It is a matter of regret that each State Geological Corps finds it expedient to adopt its own nomenclature, and for local reasons generally. We concede the necessity of localizing by subdivisions, when the details of a classification are required, but is it not too often the case that other views than merely illustrative ones enlarge divisions and classifications unnecessarily? New

York, Pennsylvania, and Virginia, has each its system. In New York the upper silurian has been called Oneida, Medina, Clinton, Niagara, Onondaga, &c. groups; in Pennsylvania and Virginia, Formations IV, V, VI, and Levant series; in Ohio, Indiana and Kentucky, it is called *Cliff limestone;* in Tennessee *Gray limestone* or *Harpeth Tennessee River group;* in Iowa and Wisconsin, *Formation III., Upper magnesian,* &c. &c. Again the lower silurian has it synonyme in *Stone River group* and *Nashville group.*

The analogies of the New York and Tennesseean systems are such as to afford the conclusion, that the rocks of the whole silurian basin of Tennessee correspond to the lower silurian limestones of New York.

The synonima of the various systems are ascertained only by patient study, and by being kept constantly posted up with every new survey and exploration.

Our hope is that the Report of Prof. Safford will be read by those good citizens of Tennessee who know how to read, that they will thereby enlarge and enrich their hearts, and send to their Legislature delegates who can appreciate the great and varied blessings the State possesses in her scientific men and mineral resources, and by a liberal and judicious expenditure, prosecute with energy the exploration of her buried treasures, and give to her citizens and the world the benefit of her exploration in volumes that may alike instruct the mind and adorn the library as works of art.

Art. IV.—THE IRON MANUFACTURE OF GREAT BRITAIN—THEORETICALLY AND PRACTICALLY CONSIDERED. By Wm. Truran, C. E. No. 7.

(Continued from page 391. Vol. 6.)

COAL.

The consumption of coal to smelt a ton of crude iron, varies with its richness in carbon and general quality; but is also influenced by the ore, flux, and blast. Measured by their richness in carbon, and estimating that a given quantity of the anthracite coal is capable of reducing 1,000 lbs. of iron, an equal quantity of the best of the Dowlais coals would reduce 954; Pontypool bituminous, 878; and Scotch, 835 lbs.

In no operation connected with the manufacture of iron, has there been a greater reduction made in the consumption of material than in the coal for smelting. The rigid economy of fuel practised in several Welsh works, has resulted in a saving of nearly two thirds of the quantity formerly considered necessary. In 1791, the consumption of coal to the ton of crude iron averaged 6 tons, 6 cwts.; in 1821, it had diminished to 4 tons; and

in 1831, to 2 tons 5 cwts., which is nearly the quantity consumed at the present day.

The maximum consumption of coal for smelting an ore will depend on the quality and fusibility of the combined earths and the yield of iron. The silicious, from their infusible matrix, require the largest quantity of fuel in smelting; the red and hydrated hematites the next largest quantity; the calcareous require a lesser quantity; the argillaceous ores are smelted with comparative facility; but the least consumption of fuel takes place with the carbonaceous ores.

The presence of carbon, whether in chemical or mechanical combination, greatly increases the fusibility of ores. Silicious ores, which contain a portion of carbon, although abounding largely in silica, are smelted with greater facility, and produce a superior metal to those devoid of carbon. In several of the carbonates of the coal formations, silica is the predominating earth; but, owing to the carbon in combination, they are smelted with a comparatively low yield of coal. The quantity of carbon in the ore materially influences the consumption of fuel in smelting. If it is large, as in the carbonaceous ores, the yield is reduced nearly one half; and the fusibility of the metal is so great, that, with this reduced consumption of fuel, the production is augmented to nearly twice the quantity which it is possible to obtain of a similar quality, from the same furnace working on other descriptions of ore.

The consumption of fuel is affected by the richness of the ore, being greatest with the poorest ores; but when an ore contains more than 50 per cent. of metal (carbonaceous ores excepted), the consumption of fuel is not diminished below the quantity due to an ore of that richness. To produce carbonated iron from the richest ores, a quantity of shale is used, as compensation for the deficiency of earth in the ore, and to form a fluid cinder for the protection of the liquid iron in the hearth. The quantity of shale used increases with the percentage of metal in the ore, sufficient being added to reduce the average yield of the mixture to 50 or under, consequently, the consumption of fuel will be for an ore of this richness.

In smelting argillaceous ore, 50 cwts. of coal, containing 87 per cent. of carbon, is consumed for each ton of carbonated crude iron produced. This is nearly 2¼ lbs. of carbon to each lb. of iron; this proportion holds good with coals containing less carbon, the quantity of coal used being augmented, in the same ratio as its yield of carbon is diminished. But the circumstances which affect the carbonating powers of the fuel are numerous and of frequent occurrence.

With raw coal a given quantity of the anthracite species reduces the largest amount of carbonated iron. The semi-bituninous coals mined to the east of Merthyr Tydfil, the next largest

quantity. The Scotch is the coal most extensively used raw, but its carbonating powers are lower than either of the others.

It is with cokes as with coals—the harder and denser the coke, and the more concentrated the carbon, the greater the reducing power. A light, hollow, spongy looking coke exposes too great a surface to the action of the blast, and is consumed too quickly to yield a maximum effect; to maintain the requisite heat, the quantity is largely increased, and the consumption of carbon estimated on the amount in the raw coal, is twice or thrice the quantity with a superior coal.

The consumption of coal or coke will also depend on the hardness of the coal, and its cohesive strength to resist fracture in the blast furnace. Breakage in the furnace may occur either from the natural weakness of the coke, the great height of the furnace, the dense character of the ore, or with a soft coke, from its grinding against the ore and flux, producing a quantity of fine dust. It is only such pieces as reach the zone of fusion in a comparatively whole state that contribute to the maintenance of the high temperature. The small pieces and dust, are injurious to the action of the furnace, and do not contribute to the carbonization of the metal; as much carbon, then, as they may contain has to be added to the charge of unbroken coke. The presence of dust and small cokes is seen by the constant discharge of the tunnel head, and under the tymp, especially after casting.

The consumption of cokes is increased when they contain much water. A portion of the calorific power of the carbon is expended in vaporizing the water; and from the cooling of the surrounding materials by the heat thus rendered latent, the carbonating power is further diminished. If this water amounts to 12 per cent. by weight of the coke, not an unusual circumstance, the smelting power of the fuel is diminished; first, 12 per cent., the weight of the water; secondly, 12 per cent., the fuel consumed in vaporizing this water, and restoring the temperature of the materials; altogether, a diminution of 24 per cent. This diminution of reducing power has to be met by an increased consumption. If 36 cwts. of dry cokes sufficed to produce carbonated crude iron, the consumption of wet coke will be 45.5 cwts. to produce the same degree of carbonization. But the consumption of wet coke is usually greater than this, which we account for by the fixation of oxygen, and the partial disintegration of the pieces by the escaping vapor.

The admission into the furnace of water, in any form, is attended with an increased consumption of fuel. If it enters with the ore, the increase in the quantity of fuel will be in proportion to the degree of saturation; but at all times, for the reasons given, be in excess of the quantity necessary to evaporate the water.

Where water enters the furnace through the tuyere, in the

form of moisture in the blast, the consumption of fuel is increased in proportion to the increase of moisture over that usually existing in the atmosphere. Water exists in comparatively dry air to the extent of 1 per cent.: in the 13 tons of blast thrown in for each ton of crude iron it weighs 2.6 cwts. A portion of the 2¼ lbs. of carbon to each pound of iron is consumed in decomposing this water; but for any excess over this quantity a corresponding increased consumption of fuel takes place. In a damp state of the atmosphere, the moisture in the blast is 3 or 4 cwts. in excess of this weight; for its decomposition, and to compensate for the caloric thus rendered latent in a vital part of the furnace, an equal or larger weight of carbon is consumed.

In consequence of the greater quantity of moisture in the atmosphere, the quantity of water conveyed into the furnace along with the materials at top and blast at bottom, occasions a larger consumption of fuel in summer than winter. By referring to the monthly yields of materials at the Dowlais furnaces, we find that the difference is very considerable, probably more than is generally believed. Taking the average of 5 years, selected at intervals of 5 years, during 22 years working, we find that the yields of coal per ton of crude iron produced at the foundry-iron furnace were, in the winter months, 49.7 cwts.; spring, 52.2 cwts.; summer, 53.1 cwts.; and autumn, 55.4 cwts.; the excess of the autumn over the winter months, 5.7 cwts, is equal to an increase of 11 per cent. Proceeding in like manner with the forge-iron furnaces we find that the yields in the winter months were 43.6; spring, 44.2; summer, 44.6; and autumn, 45.8 cwts.; the excess of autumn over winter, 2.2 cwts., is equal to 5 per cent. The variation in the seasons is still greater with the ballast-iron furnaces, the yields in winter being 43.2; spring, 44.1; summer, 50.1; and autumn, 49.5; or 6.9 cwts. over the winter, nearly equal to 15 per cent.*

The yield of fuel is diminished when caustic lime is substituted for limestone. The diminution in the weight of carbon is nearly equal to one third of the difference between the weight of the caustic lime and the limestone. If the burden of 17 cwts. of

* The greater uniformity in the forge-iron yields we attribute to the variation in the composition of the burden. The average consumption of hematite ores, was in winter 6.6 cwts.; autumn 8.8; and of cinders 8.3, and 11.8 cwts. With this increase of hematite and cinders, in autumn, the yield of ore was reduced from 47 to 41.2 cwts. A heavier burden of rich Lancashire ore and forge cinders, without the addition of clay or other material to improve the quality, would result in a diminished yield of fuel, such as appears in the accounts of the forge-iron furnaces.

Throughout the Welsh works the consumption of primary ores is largest in summer and autumn. In these seasons, the trade in sea-borne ores is prosecuted with the greatest activity, and the manufacturers are in consequence well supplied; but in winter and spring the falling off in the shipments causes a larger consumption of the local ores.

limestone be replaced by its equivalent of caustic lime, the burden will be 10 2 cwts.; the reduction in weight being 6.8 cwts., one third or 2.26 will give the reduction in the weight of carbon consequent on the substitution. If the coal yields 87 per cent. of carbon the reduced consumption will be equal to 2.57 cwts. of coal.

But against the diminished consumption of coal in the blast furnace, there must be placed the quantity consumed in calcining the limestone. This will amount to 1.5 cwt. on the ton of stone, equal to 1.3 cwt. on the ton of iron, leaving an apparent saving of 1.3 cwt. only; but the value of the large coal saved from the furnace is greatly above that consumed in the kiln, wherein slack or other small coal, which cannot be used in the furnace, and would otherwise be completely valueless, may be consumed.

Raw coal reduces and smelts a greater weight of ore than the coke from such coal. At one period of the manufacture, the use of charred coal was universal; but within the last 25 years numerous furnaces have been worked on raw coal. The number of coals which may be advantageously used in the existing furnaces, in the raw state, is not large; but wherever the change from coke to raw coal has been effected, the results are greatly in favor of raw coal. The advantages are greatest with coals which lose considerably in weight in coking, and least with those approaching the anthracite structure. The best of the furnace coals raised at the Dowlais collieries, contains 87.3 per cent. of carbon, and 2.1 per cent. of ashes. These coals lost in coking under the most favorable circumstances 25 per cent., thus reducing the weight of the coke below the contents of carbon. A portion of the carbon was consumed in the process, consequently was unavailable for smelting. The quantity thus consumed is represented by the difference between the weight of the carbon and ash in the coal, and that of the coke obtained. The carbon and ash in the Dowlais coal amounts to 89.4, the coke weighs 75, leaving a loss of 14.4, or nearly 16 per cent. of the smelting power. With this certain loss from using coke, the raw coal having its carbon undiminished, should carbonate a greater weight of crude iron, and in practice it is found to do this. Prior to the use of raw coal in the furnace, the coal used for coking averaged 50 cwts. to the ton of crude iron, of mixed qualities; but since the abandonment of coking, this weight of iron is smelted with 45 cwts.

In Scotland the use of raw coal is attended with a still greater reduction in the quantity consumed. The furnace coals of that country average 76.4 of carbon, and 6 of ash,— total of carbon and ash, 82.4 per cent. They lose 55 per cent. by weight in coking, or 37.4 below the amount of carbon and ash. This loss of 37.4 parts out of 76.4 is equal to a diminution of nearly 50 per cent. in the smelting power of the coal. If the carbon in

38 cwts. of raw coal is sufficient to reduce one ton of crude iron, the preliminary operation of coking would result in the consumption of coal being doubled. Formerly, when coke was used throughout Scotland, the consumption of coal ranged from 4 to 6 tons to the ton of crude iron.

The consumption of fuel is increased whenever the working of the furnace is deranged from causes connected with the ore, flux, or blast; in a similar manner, and to the same, if not to a greater extent, than the increased consumption of ore. The restoration of the furnace to a healthy state is not accomplished without large additions to the quantity of fuel, or what in effect is the same—a reduction of the burden of ore, and flux,—that a higher temperature may be attained in the hearth, for the fusion of the refractory mass adhering to the sides of the hearth, and around the tuyeres. The proportion is increased according to the exigencies of the case, from 45, the usual yield, to 60 or 70 cwts. to the ton of iron.

We have stated that the consumption of fuel per ton of iron made is smallest with the carbonaceous ores; but if their richness in metal and carbon, and great fusibility be considered, the consumption of fuel is excessive. The consumption averages 38 cwts. of a coal containing 76 per cent. of carbon, equal to 3,234 lbs. To this must be added the carbon mechanically combined with the ore in the proportion of 30 to 28 of ore, equal to 2,400 lbs., or a total of 5,634 lbs., exclusive of the coal used in the hot blast stoves. The average consumption with the argillaceous class is 4,480 lbs., or 1,154 lbs. less than the carbonaceous. Judging from the greater consumption of carbon in smelting the latter, it might be inferred that the metal was extracted with difficulty; but such is not the case in practice. It is now well known to be the most fusible iron ore wrought. Yet for its reduction, fully one third more carbon is expended, than is found necessary with other ores melting at a much higher temperature. But if the consumption be estimated on the quantity of fluid products obtained, the excess of carbon in smelting these ores is still more apparent.

The consumption of fuel is reduced when a hot blast is substituted for a cold. The diminution is considerable in some districts, but in others it is trifling and scarcely compensates for the outlay on the heating stoves. In Scotland the reduction in the consumption of coal in the blast furnaces smelting carbonaceous ores varies from 10 to 20 cwt. In consequence of the low temperature at which the ore melts, a simple wind draught being sufficient, the increase of temperature from 50 to 610 approaches to the melting point of the materials; and the carbon previously consumed in the furnace in elevating the blast to this temperature, may be withdrawn. But with the more refractory ores the reduction is not so great. The elevation of the temperature of

the blast to this degree bears a much smaller proportion to the subsequent elevation in the furnace, therefore the saving by heating is in a similar reduced degree. The reduction in the consumption of fuel in the furnaces of Wales amounts to from 8 to 10 cwts. of coal under favorable circumstances.

Against the saving in furnace coal, however, there must be placed the coal used in the stoves to heat the blast. The quantity usually required for this purpose is 5 cwts., but the coal consumed in the stove is of an inferior description, incapable of being used in the furnace for smelting. The saving in fuel, then, by a hot blast, the relative values of the furnace and stove coal being considered, may be estimated at 13 cwts. in Scotland, and 7 in Wales.

There is an opinion current amongst furnace managers that any excess of coal over the quantity absolutely required for smelting, is merely so much waste. We are of opinion that when a larger quantity of coal is used, without a corresponding augmentation of the volume of blast, the additional fuel is decidedly injurious to the working of the furnace, to the quantity, and to the quality of the crude iron.

For the complete combustion of the carbon of the fuel, a definite quantity of oxygen gas is required, to furnish which, a sufficiency of atmospheric air must be supplied for decomposition. The temperature attained will depend entirely on the volume of air supplied in a given time. If through any mechanical arrangement, the admission of the necessary quantity is distributed over a lengthy period, the rate of combustion will be proportionably slow and a minimum temperature attained. But if the quantity admitted be increased, the combustion of the fuel proceeds more rapidly; the same quantity of caloric is evolved as with the slower combustion, but in consequence of its evolution occupying a shorter period the temperature attained is proportionably higher. Every increase in the quantity of atmospheric air admitted to the ignited fuel, in a given time, results in an increased temperature of the products of combustion. By the employment, then, of suitable mechanical means for the forced admission of large volumes of air to the carbon, almost any desired temperature may be maintained in the interior of a furnace.

The reverse occurs if the quantity of fuel is increased. For every addition of carbon a diminution of temperature takes place. The volume of air admitted is insufficient to maintain the same active combustion with the larger volume of carbon. An increase in the quantity of fuel is equivalent to a reduction in the volume of blast—in either case the quantity of oxygen to carbon being reduced, the combustion is slower, and the temperature maintained inferior. Inasmuch, then, as the temperature is lowered by its use, the additional fuel is injurious to the furnace, and crude iron is smelted.

Blast furnace managers, however, entertain a different opinion respecting the effects of an increased quantity of fuel in the furnace. Additional fuel is supposed to maintain a greater heat, and produce a superior iron; and with this impression whenever the furnace is working bad, the weight of fuel is considerably increased, frequently to such an extent, that the evil which it is intended to remedy is thereby augmented. But in corroboration of what we have advanced respecting the necessity of proportioning the quantity of blast to the carbon in the coal, we may remark, that in derangements of the blast furnace, attended with a maximum yield of fuel, a minimum make occurs, and the weekly consumption of carbon, and its relation to the volume of blast is but slightly altered.

But while the mean temperature of the hearth is lowered, by an excess of carbon, the temperature in the upper part, and in the boshes is augmented. With a rigid economy of fuel, the depth of the zone of fusion is limited, and of the caloric evolved during the combustion of the carbon by far the largest portion is immediately rendered latent, through the fusion of the ore and flux. With an excess of carbon, the zone of fusion extends higher up the hearth, and of the caloric evolved, an inferior quantity is rendered latent, owing to the reduced quantity of ore and flux used; hence the ascending gaseous column is of a high temperature, which is communicated to the solid materials through which it passes.

For the production, then, of a temporary high temperature, above the usual zone of fusion, the excess of carbon is beneficial; and the quantity of gaseous carbon in the ascending column insures the fusion of the materials at a low temperature, and the production of a very fluid iron.

With a minimum consumption of carbon, the range of fusion is contracted; the caloric evolved is immediately rendered latent by the fusion of the larger quantity of ore and flux; and owing to the ascending column containing an inferior quantity of gaseous carbon, the ore is less fusible, and when reduced, the iron is of a white quality.

The thickness of the walling around the furnace, affects the yield of fuel. When the thickness is limited to the brickwork, as is the case in numerous cupola furnaces in Wales and other districts, the consumption is sensibly increased, over that in thick-walled furnaces. At the Dowlais works, there was formerly a cupola furnace having its walls 2 feet thick. For a number of years the consumption of coal averaged 45 cwts. 2 qrs. 12 lbs. to the ton of crude iron smelted. At two adjoining furnaces, erected at the same period, working on the same materials, blown with a similar blast, and differing from the cupola furnace only in the thickness of the walls, the consumption during the same period averaged 43 cwts. 0 qrs. 19 lbs., or 278 lbs. under the

thin-walled furnace. Eventually this furnace was cased in masonry to the depth of 3 feet, which resulted in the consumption being reduced to a level with that in the other furnaces.

LIMESTONES.

The consumption of limestone is dependent on its richness in lime, and in the quality and quantity of the earths combined with the iron. With the same ores, the consumption will vary with the percentage of lime. If the yield be about that of an average good limestone, the quantity for argillaceous ores yielding 48 per cent. of metal, will be 15 to 20 cwts. per ton of crude iron. This is for a limestone yielding about 54 per cent. of lime. If the yield is lower, and silex is present in large quantities, the consumption may be roughly estimated by adding the silex to that combined with the ore, and charging a sufficiency of limestone to produce the lime necessary for their fusion.

As the species of iron ores smelted in this country are not numerous, nine tenths of the crude iron being smelted from argillaceous and carbonaceous ores, we may state in reference to them that the consumption of lime will generally be in proportion to the quantity of silica, and inversely as the quantity of lime in their composition.

An approximation to the quantity of limestone necessary for fluxing, sufficiently accurate for all practical purposes may be made, if the quantity of silica entering the furnace is known. We have invariably found that, where a cinder comparatively free from iron was produced, the quantity of lime was nearly equal to the silica; but in no instance have we known a furnace work well when the consumption of lime was considerably less.*

When the silica bears a very small proportion to the alumina, the consumption of limestone will be larger than we have stated; but we may remark, that in the mass of ores smelted in this country, the proportion of silica to alumina on an average is fully as high as three to one; therefore, it is on the quantity of silica that we have to calculate the flux.

If the limestone yields a low percentage of lime, the consumption is rapidly augmented, and the expenses of smelting largely increased.

*By referring to the analysis of ores, fuels, and fluxes, given in Section I., and calculating the quantities from the yields given in other sections, it will be seen that the lime and silica are nearly equal in weight. In the blast furnace cinders, it will be observed that the percentage of metal is least when the lime and silica are nearly equal, but is highest with an excess of silica. We have known furnaces to work several months without the usual complement of flux, or its equivalent in other respects; but in every instance the value of the flux and fuel saved was inferior to that of the iron in the cinder, which ranged from 10 to 20 per cent., or from 20 to 40 per cent. of the metal in the ores consumed.

It is not unusual for limestone to contain 5 to 10 per cent. of silex, and in some specimens as much as 25 per cent. of this substance is present. The purest carbonates contain from one to two per cent. With the knowledge then, that, for the fusion of the silica in the limestone a corresponding weight of lime is used, we see the importance of employing a stone as free as possible from this earth. If silica is present to the extent of 8 instead of 2½ per cent., the yield of lime is reduced to 51, from which 8 parts must be deducted for fluxing the combined silica, leaving 43 parts only for the reduction of the ore, instead of 52.5. Under such circumstances an increase of 5.5 of silica is followed by a diminution of the fluxing powers of the limestone of 18 per cent., and instead of the present consumption of 17 cwts., the excess of silica would raise it to nearly 21 cwts. The consumption of fuel is increased in the same ratio as the weight of liquid products, and the loss of metal in the same ratio as the enlarged volume of cinder.

An exceos of limestone over the quantity absolutely required for fluxing the combined earths is injurious, inasmuch as its fusion renders latent a quantity of the caloric evolved by the fuel, which to this extent is weakened in its reducing powers. The temperature in the hearth is lowered, and the separation of the metal rendered less perfect. If the lime is greatly in excess, and the consumption of coal is augmented in proportion, the resulting crude iron possesses all the characteristic properties of iron smelted from calcareous ores. The red-short principle is strongly developed in the finished bar, and the strength and general quality sensibly deteriorated.

BLAST.

The consumption of blast is immediately dependent on that of the fuel. Chemically, one pound of carbon burnt to carbonic acid requires the oxygen of 153 cubic feet of atmospheric air. But in practice we do not observe any relation between the quantity of carbon and volume of blast. In a very few instances we have observed that the quantity of air supplied has been in excess of the chemical requirements of the fuel, but in the majority of furnaces the supply ranges from 40 to 90 feet, or from about one fourth to one half of the actual requirements. The wide margin between the supply in practice, and chemical requirements of the fuel consumed, will form a portion of our inquiry on the effects of a heated blast, as exhibited by an economy of furnace fuel beyond that due to the consumption in the heated stove.

The effects produced on a furnace by an insufficient blast, are a waste of fuel, a lowering of the temperature, and the production in inferior quantities of a metal more or less debased by the presence of impurities,—carbon especially. In the smelting, and in

deed in all other operations connected with the manufacture of iron, where heat is essential, a high active temperature conduces to economy of time and materials. In the more advanced processes of the manufacture, where the effects of heat are more readily obsrevable, a dull heavy draught results in a loss of time a rapid waste of the metal, a large consumption of coal and the ultimate production of an inferior bar. Similar effects cannot fail to be produced on the operations within the blast furnace whenever the supply of atmospheric air is inadequate to maintain active combustion.

A volume of blast greatly beyond that required for supplying the oxygen necessary for complete combustion of the fuel can be attended with no beneficial effects, but the reverse. The air which is not decomposed to supply oxygen, ascends with the gaseous products of combustion, and by rendering latent a portion of the caloric evolved by the fuel, reduces the general temperature of the surrounding materials. An excess may therefore produce injurious effects, scarcely inferior in magnitude to those produced by a deficient supply.

CIRCUMSTANCES AFFECTING THE QUALITY OF THE CRUDE IRON.

The quality of the crude iron produced from a furnace, working with a given ore, will be affected by various causes; but the most common are the variable qualities of fuel and flux used variations in the pressure, and volume of blast and the state of the atmosphere. It is probably more dependent on the fuel than the other materials. If the coal or coke is deficient in carbon, and contains a large percentage of earthy matter, it is unsuitable for smelting. The higher qualities of crude iron cannot profitably be manufactured with such coal. And experience has demonstrated that if the fuel contains a notable percentage of sulphur, it is not adapted for the production of the finest qualities. The sulphur is partially expelled during the process of coking, but its complete volatilization cannot be effected by the heat of this operation. A portion is therefore present in the fuel when it reaches the hearth and, combining with the metal, contaminates its qualities by diminishing its strength and other properties.

A weak coal, if used in the raw state, is very liable to be splintered by the high temperature of the ascending gases immediately that it is precipitated into the narrow throat of the furnace. The cohesion of its particles is weakened, and ultimately destroyed, by the rapid expansion and escape of its volatile constituents. The detached portions descend with the materials, filling up the interstices, and obstructing the passage of the ascending column of gases, and their free action on the ore; on arriving at the hearth they drop through the melting zone below the direct action

of the blast, and from whence they are discharged with the escaping gas under the tymp, or cleaned from off the cinder. Deprived of the beneficial effects of a considerable portion of the carbon of the fuel, the metal produced is of a quality below that due to the composition of the fuel; and owing to the inferior heat maintained at the tuyeres, the metal in separating from the cinder usually has combined with it a large percentage of the predominating earths.

If a weak coal is coked before entering the furnace, its injurious effects on the quality of the metal are equally apparent. The coke produced being of a light spongy character, offering an extended surface for the action of the blast, an intense local heat is maintained, and the fuel consumed too rapidly for the production of metal of a high quality.

If the coke has been overdone by allowing the coking process to proceed too far; a portion of the carbon will have been consumed; and as the proportion of coke is generally measured by barrows of a given capacity, the same bulk of overdone coke will contain less carbon than if properly prepared. Its power of carbonating the metal therefore will be diminished, and since a slight reduction in the quantity of carbon is perceptible in the quality of the metal, the employment of such coke invariably results in an immediate deterioration in the degree of carbonization.

Under the old system of coking in the open air, the coke produced were seldom overdone. The conversion of the coal into coke was the operation of several, generally 8 or 10 days, and being open to inspection the combustion of any portion of the mass was under the control of the workmen. Lately, however at several works the process has chiefly been conducted in brick ovens. A greater yield of coke is supposed to follow, but from our own observation, we do not find that this increase of yield is at all commensurate with the defects of the coke so prepared. The operation is conducted with great rapidity, three or four tons of coal being charged into an oven, coked, and withdrawn in 24 hours. We have yet to learn that this high pressure system produces coke capable of carrying a higher or even as high a burden as others prepared under a different system. Certain it is, that cokes prepared in ovens, are commonly either over or underdone, and the quality of the metal and working of the furnace is most variable.

The use of coal, partially coked, deranges the working of the furnace, and has an injurious effect on the quality of the metal. The deterioration of quality will be more or less according to the character of the coal, and temperature of the throat. If of a highly bituminous nature, swelling considerably in coking, and the temperature of the throat be high, the deterioration will be greatest; but if of a semi-bituminous character, increasing little in bulk, and the temperatnre of the throat be low, the deterioration will

be considerable. The cause of the deterioration from partially coked coal, probably, is owing to the hydrogen and other volatile substances remaining in the centre. On being suddenly heated in the furnace the coking process recommences, the interior mass of coal expands, bursting into fragments the outer case of coke and the violent expulsion of the volatile constituents of the uncoked mass so weakens the cohesion of its particles, that it is crushed by the weight of superincumbent materials. In the hearth the disjointed fragments of coke are incapable of maintaining the temperature necessary for the production of carbonated metal the usual quality under such circumstances being white or mottled.

A large quantity of inferior coke is now prepared from the small of bituminous coal. The coking of small coal for smelting is of very recent date. If prepared directly on extraction from the workings, and the operation is carefully conducted in ovens, a coke is produced scarcely inferior to that obtained from the large coal in the same way. But if allowed to remain for a period, stacked in large heaps, as we have frequently observed, the coke produced is of a very inferior quality. This inferiority is readily accounted for. Whilst lying in the heap, the evolution of gas under a considerable pressure, generates a slow spontaneous combustion of the volatile portion of the coal. If examined after, or while this is going forward, the coals in the centre of the heap will be found bearing evident signs of a partial charring, having lost their bituminous character, and presenting appearances similar to those of underdone coke. Charged into the oven, this heated small coal is converted into a hollow, spongy coke, of so weak and friable a character, as to be entirely unsuitable for furnace purposes. If used in the furnace it shares the fate of all very weak cokes having a considerable burden of materials, in being crushed, and a portion ground to dust by the descending materials. The metal produced will be inferior in quantity and quality to that from an equal weight of coke prepared from fresh small coal.

Coke containing a large quantity of water is at all times injurious to the quality of the metal. The majority of the cokes prepared will absorb water to the extent of 10 to 14 per cent. of their weight. Under the old system of open fires, water was not generally used for cooling the coke, and a considerable quantity, therefore, could be obtained for the furnace in a comparatively dry state. But, though water was not used for cooling the fires, the cokes often were saturated from exposure to the weather. Where the operation is performed in ovens, the common practice is to cool with water immediately after drawing; a large quantity consequently becomes fixed in the coke. This employment of water doubly impairs the reducing power of the coke. In the first place, the volumes of water showered on the redhot mass causes an irregular cooling, the whole is ruptured into fragments

by the unequal contraction, but a number of the pieces are too small to carry a proper burden of ore. The larger pieces from being suddenly cooled are weakened, break into smaller pieces when heated under pressure, and also carry a small burden. In the second place, the water absorbed by the coke is vaporized by the heat of the furnace.

This is attended with a direct consumption of fuel, thereby reducing the carrying power of the coke. But the presence in the furnace of water in any form is injurious, and when it is introduced along with the materials at top, lowers the temperature in the throat and body of the furnace. This reduction of temperature in the superior regions is equivalent to a reduction of the height of the furnace, and a corresponding diminution in its smelting power. In consequence of the inferior temperature prevailing, the upper portions of the furnace are comparatively ineffective in the reduction of the ores. The production of carbonated iron from ores of the argillaceous class, requires that the materials should be in the furnace 40 hours, exposed to the heat and gases produced by the combustion of the fuel. If, then, the effective working height of the furnace is from any cause diminished, the descending materials will be a shorter period in the effective portions of the furnace. The deoxidation and carbonization commence at a lower level than usual, and is imperfectly accomplished at the period of fusion. The resulting metal, therefore, will be of an inferior quality, and generally the cinders produced under such circumstances contain a high percentage of metal.

Coals, used in the raw state, undergo the process of charring, during their descent in the furnace. Those containing much bituminous matter require coking before entering the throat of the present furnaces; but at several works a portion is used raw. The quality of the metal produced with raw bituminous coal—entire or mixed—is usually very inferior. Increasing rapidly in bulk, when heated they press with the other materials against the sides of the furnace with such force, that the mass remains immovable for several hours, during which time the operation of filling is discontinued. In the mean time the descent of the materials below the obstruction continues, leaving a vacancy of less or greater depth according to the time and rate of driving. The suspended materials remain fixed in their position until the coal having attained its greatest bulk, combustion proceeds, followed by a diminution of bulk and the liberation of the materials, which then suddenly descend several feet to the surface of the other charges.

With the smelter this suspension of the materials is termed "scaffolding," and the subsequent sudden descent "jumping." The time which the materials remain fixed is measured by the number of charges which the furnace would have gone during

the period of suspension. When the obstruction is removed the furnace is said to jump so many charges. Scaffolding may occur from other causes, but we have found it very common with furnaces using bituminous and other raw coals. The injury to the metal from this retention of the materials is very apparent. It changes in a few hours from a warm, free, running gray, to a cold, thick, white of the worst quality. When we consider the changes wrought during the retention, any other result cannot be expected. A portion of the carbon has been consumed, and the reviving powers of the fuel are thus diminished. On its sudden descent the partially consumed coke is broken into smaller pieces, still further reducing its power. This diminished carbonating power of the coal, is alone sufficient to alter the quality of the metal from gray to white; but the production of a superior metal is otherwise rendered impracticable. To produce such metal, the ore must be in the furnace the requisite time for its complete deoxidation and carbonization before reduction, otherwise, the quality is white. When the furnace is scaffolding, the materials are in the usual period, but the time during which they are suspended below the throat, beyond the influence of the reducing medium must be deducted. If they remain stationary for 10 or 12 hours, a very common occurrence, the time for deoxidation and carbonization will be reduced to this extent. Therefore, instead of the descent occupying 40 hours as with carbonated iron, it is reduced to 28 or 30.

Such obstructions occasionally occur with coal sparingly supplied with bituminous matter. With the knowledge, however, that nearly every kind of fossil fuel expands when heated, there is no difficulty in accounting for scaffolds, and their injurious effects on the quality of the metal. If a high temperature is maintained in the throat, the expansion of the fuel is most rapid, but if a low temperature, the full expansion is attained at a depth of 17 or 18 feet, where, from the larger diameter of the furnace, the liability to form scaffolds is greatly diminished. But the total increase in bulk is much less in the semi-bituminous; and since it is the rate, and amount of expansion which determines the risk from obstructions, coals which increase but slightly in bulk during the coking may generally be used in the raw state in the present blast furnaces with satisfactory results.

A prominent disadvantage attending the use of raw coal, which contains a large percentage of volatile gases, is the comparatively low temperature which prevails in the throat and upper portions of the furnace. The gases and aqueous vapor distilled from the fuel, combine with the ascending column of heated gases, reducing their temperature and that of the adjacent materials to a degree incompatible with the perfect deoxidation and carbonization of the ore before reduction in the hearth.

The use of coal broken small is attended with an immediate

deterioration of the quality of the metal. It is rarely that such coal is introduced intentionally,—all the fuel for the furnace, whether coal, coke, or charcoal, being filled into the barrows by "Pikes" formed of iron bars, having a space of one half, or three fourth inch between each. But if finely broken coal or coke, from any cause, gains admittance in considerable quantity, as part of the fuel, the injury to the furnace and to the metal may be very great. We have ascertained that a proportion so low as 7 per cent. of the weight of the fuel, will change the quality from dark gray to mottled and white; and if this proportion be exceeded, the deterioration is still greater. That this change should result from the presence of a small percentage of small coal may appear surprising, but if it is considered that for the production of one pound of dark gray iron a definite quantity of carbon is consumed—no portion of which is supplied by the small—it is seen, that, whatever proportions the small bears to the large coal will the carbonating powers of the fuel be diminished.

Injurious effects similar to those which result from using coal of a weak friable character are caused through exposing the coal to the atmosphere for a few weeks only. It is a peculiarity of several of the Welsh coals, that if stacked in heaps they deteriorate in quality; lose a great portion of their calorific power; the cohesion of their particles is diminished; and finally if suffered to remain, disintegration commences, and the whole heap crumbles into small pieces. The carbonating power of the coals will depend on the length of exposure and season of the year. Under ordinary circumstances, three months exposure will reduce their carrying power one third; six months more than one half; after this they cannot be used in the blast furnace with safety, for, on the application of heat, they dissolve into small fragments.

The defective carbonating powers of the carbon in small coal, broken coke, or other fuel in small pieces, when compared with that of large coal may require some explanation. It is known to smelters that a given quantity of large fuel, yielding a certain percentage of carbon, will smelt and carbonate a stated quantity of metal, but with the same fuel in smaller pieces, carbonated metal cannot be produced, and if broken very small, the effect is to stop the smelting operation. The quantity of carbon charged into the furnace is the same in each case, but the results are widely different. Whence this inferior power of broken coal? We are of opinion that it arises from two causes—firstly, from the small dimensions of each piece, the coal is partially consumed in the upper regions, and the portion which descends disappears before the blast too rapidly for the requisite quantity of gaseous carbon to combine with the metal; secondly, from the blast acting on a number of disjointed pieces, the mean temperature maintained is too low for carbonization, and the perfect separation of the iron; hence the production of an inferior white iron.

The quality of the limestone used as flux, and the manner in which it is filled into the furnace, affects the quality of the metal. Limestone in the raw state is generally used for fluxing. If broken small before it enters the furnace—say into pieces of not more than one lb. each, the raw stone works well, and the cinders produced with carbonated metal will be of an even quality; but if larger pieces are used—and furnaces may be found where the pieces range from 5 to 20 lbs. each—the effects will be observable in the inferiority of the metal, as well as in the altered appearance of the cinder, which from its former smooth flow and even surface, will now be obstructed by pieces of partially fused lime. The larger the pieces of limestone charged, the more apparent will be the alterations in the general character of the metal and cinders. On the other hand, the smaller the stones the more easily are they fused, and the more readily will they unite with the earthy matrix of the ore, forming a fluid cinder from which the metal separates with comparative facility. When large stones are used, the heated blast fuses a portion of their exterior only, this unites with the other earths to form cinder, but in the mean time the unfused mass is descending and ultimately floats on the melted materials in the hearth. Deprived of the beneficial effects of so much lime, the cinders produced will be deficient in liquidity, and owing to the imperfect separation of the metal will contain a larger quantity of iron. Examined when cold, the cinders will be found dark colored, and spotted with lumps of partially fused lime.

Apart from the impossibility of reducing large masses of lime in the limited time which the heated blast can act on them, in their rapid descent in the hearth, they occasion a considerable diminution of temperature in the interior of the furnace. The introduction of raw stones, broken small, will occasion a diminution of temperature in the throat and superior parts of the body, in consequence of the large amount of caloric rendered latent during the calcination. This reduction of temperature will occur whether the stones be large or small, but there is an advantage in using the smallest, inasmuch as they are quickly calcined, and absorb the necessary caloric at or near the throat, where its loss is least felt. With large stones, however, the calcination is protracted to a low level in the furnace, where the reduction of temperature has the effect of impairing the quality and quantity of the metal.

At some works the limestone is calcined previous to being used in the furnace: the operation is performed in kilns similar to those employed in calcination of ores. The stone loses about 40 per cent. of its weight through the expulsion of carbonic acid and water. To this extent the weight for fluxing may be reduced below that of raw limestone. The beneficial effects of lime are considerable: the temperature at top is not diminished as

with raw stone; to this circumstance we ascribe the fact of a given weight of fuel carbonating a greater weight of iron with calcined than with raw limestone. Yet with this important advantage calcined limestone is not extensively used as a flux, probably the readiness with which it absorbs moisture from atmospheric air is an objection. If care is not taken to have it promptly conveyed to the furnace, the water absorbed will scarcely be inferior in weight to that of the carbonic acid in the original stone.

The effects produced on the quality of the metal by change in the atmosphere, are important and constantly recurring. It is known that the metal produced in winter and spring is, with similar volumes of fuel, of a superior quality to that produced in summer and autumn; it is also known that the difference in quality is due to atmospherical changes; but the immediate cause is not so well understood.

We have already stated that the introduction of water into blast furnaces is attended with the most prejudicial effects. At certain seasons of the year the atmosphere contains a considerable quantity of water in the form of vapor, which is forced into the furnace through the tuyeres; at other periods it holds water in the form of rain, which, descending on the materials collected for smelting, saturates them, and is thus conveyed into the throat of the furnace. With a wet atmosphere, then, water is discharged into the furnace at top with the solid materials, and at the bottom with the blast.

In the dryest seasons, the moisture thus entering the furnace weekly will weigh about 20 tons; but with a prevalence of low wet weather, it will exceed 100 tons, or nearly 20 cwts. of water to each ton of crude iron produced.

The deteriorating effects which such volumes of water have on the quality of the metal is very apparent. With a dry, easterly wind, the quality and make will be greatly superior to that obtained with the wind from any other quarter of the compass. A sudden shifting from east to south-west occasions a deterioration in quality from dark to bright gray, and, if the alteration continues, from gray to mottled and white.

An excess of blast results in a deterioration of quality. For the production of carbonated crude iron, the velocities of ascent of the gaseous, and descent of the solid materials are confined within certain limits. If these velocities are accelerated, by employing additional blast, without a corresponding augmentation of the volume of carbon, the resulting metal will be less carbonated.

CIRCUMSTANCES AFFECTING THE PRODUCE OF CRUDE IRON.

The produce of carbonated crude iron from blast furnaces of a given capacity, and blown with a fixed volume of blast, will

be affected chiefly by the richness of the ore, the quality and quantity of the fuel, and to a minor extent by the quality of the flux and blast. The smelting power of the furnace is limited to the production of a definite quantity of liquid material in a stated time. With the argillaceous ores, the production is at the rate of 28 cwts. per week, for each yard capacity of furnace. This rate of production cannot be exceeded without deteriorating the quality of the crude iron. But with a rich ore, the produce of metal may be augmented, the quantity of cinder being diminished in a similar ratio, so that the gross weight of iron and cinder will not be increased. If an ore yielding 36 per cent. of metal when calcined be employed, 3 tons will be required to produce one ton of metal, but if an ore containing 44 per cent. be employed, 48 cwts. will be sufficient.

The time required for deoxidation and carbonization is 40 hours; if the furnace smelts the lean ores at the rate of 28 cwts. of liquid matter per yard capacity, it must smelt this quantity with the richer ores. But the proportion of metal to cinder, which with the lean ores was as 7 to 18, is as 8 to 17 with the rich ore. The make of metal therefore is augmented in this ratio.

There is however a limit to this increase of production by using rich ores. The materials must be in the furnace the stated time, and the gross weight of liquid products not exceed 28 cwts. If very rich ores are used, owing to the additional clay and lime necessary as flux, and the large consumption of fuel consequent on their addition, the proportion of metal to cinder is not sensibly increased, and the rate of production remains unaltered.

An exception must be made in the case of the carbonaceous ore so much used in Scotland. This ore yields after calcination from 44 to 64 per cent. of metal; the average is nearly 60 per cent. The matter combined with the metal consists of carbon, oxygen, alumina, silica and lime, the last about 5 per cent. of the weight. In consequence of the presence of this lime, and the small percentage of other earths, the quantity required for flux is usually less than 6 cwts. The carbon is consumed before the blast, when the earthy matrix of the ore uniting with the lime, cinder is formed, but in comparatively small quantities. With argillaceous ores the weight of the cinder will at all times be nearly twice that of the metal, but from the peculiar manner in which the carbon is combined with the metal in the carbonaceous ore, carbonated crude iron is produced with not more than an equal weight of cinder; and instead of 28 cwts. of liquid matter per yard capacity of furnace, 34 cwts. is commonly obtained.

The produce is affected by the qualities of the fuel. A hard, dense, semi-bituminous coal containing a large percentage of carbon, and yielding little ashes, will reduce the largest quantity

of metal. Cokes prepared from coal too bituminous for use in the raw state, will reduce metal in proportion to their density and carbon. The smallest produce is obtained with a weak friable coal, or the coke prepared from such coal. Since the height of the blast furnace has been increased to 45 feet, a blast of 2½ to 3 lbs. to the square inch has become general. But with the weakest cokes this pressure of blast is attended with an increased consumption of fuel, if the make and quality of the crude iron is to remain unimpaired.

With coals which expand considerably in coking the produce will be lower with the coke than with the raw coal. The coke, consisting chiefly of carbon alloyed with the earthy matters of the coal is qualified for the immediate action of the blast, and undergoes little alteration in its descent to the hearth; but bulk for bulk the coke does not contain so much carbon as coal. Occupying then a greater space, the quantity of other materials in the furnace is diminished, the time of descent being the same, the quantity smelted, and the produce of metal is diminished in the same ratio as the quantity of materials.

The quality of the limestone used as a flux will influence the make of crude iron. If it contains a notable percentage of alumina and silica, its reducing power is diminished by nearly three times the weight of these earths. Their presence in quantity is equal to the disadvantage of a lean ore, fuel and lime being required according to the weight of silica and alumina entering the furnace. The additional materials occupy space in the furnace without contributing to the produce of metal; and for their admittance a proportionate quantity of ore must be withdrawn from the burden. The quantity of cinders in proportion to metal will be increased by the quantity of earths in the limestone, and the lime necessary for their fusion. Hence, the make will be diminished from the lower yield of the liquid products.

The smaller space occupied by caustic lime and its comparative lightness and freedom from moisture, favors the produce of the furnace. Where it is used, an increase of 4 to 5 per cent. is observed in the make. This is accounted for, by the reduced consumption of fuel, and lesser space occupied by the caustic, enabling the furnace to carry a richer burden.

The produce is influenced by atmospherical changes in certain seasons of the year. It is well known to smelters, that, with materials of similar quality, and volume of blast unaltered, the make of a furnace is greater in the winter months than at any other season. The reason of this greater make in winter, was, until within the last few years, ascribed to the coldness of the air. On the application of the hot blast invention to the manufacture of iron, this superiority of cold winter over warm summer air was adduced as a reason against using heated air. The greater efficacy of the cold air was by some writers ascribed to

its greater density, which is in proportion to the decrease of temperature. Hence, a given volume of air contains more oxygen in winter than summer. The cause is now generally ascribed to the dryness of the atmosphere in winter as compared with its condition in summer.

Taking for our guidance the make of the 18 furnaces at the Dowlais works, for a period of seven years, we find that the actual increase of make in winter over that in summer, premising that the furnace is working on a similar burden, is between 4 and 5 per cent.; but with this increase there is a marked improvement in the quality of the crude iron obtained.

With the same burden of fuel and other materials the produce and quality will be directly dependent on the volume, and indirectly on the density of the blast. The produce will be in the same ratio as the volume of blast; but the quality, measured by the degree of carbonization, will be in an inverse ratio. The rate of production is more or less rapid according to the volume of blast brought in contact with the carbon; a large volume insuring a rapid combustion of the carbon and fusion of the ores, and *vice versa.* With an augmentation or reduction of the volume, the velocities of the solid and gaseous columns are augmented and reduced in like manner, and the quality impaired or improved with every variation in the velocity.

With the same volume of blast, the produce, within certain limits, is in an inverse ratio to the quantity of carbon to other materials in the descending column. For the fusion alone of the materials, the consumption of carbon ordinarily is under 20 cwts. to the ton of crude iron. Since the velocity of reduction is dependent on the rapidity of combustion with a minimum proportion of carbon, the maximum produce of inferior iron is attained. On the other hand, an unnecessarily large supply of carbon is followed by a minimum produce.

The increased produce of blast furnaces within the last 70 years is shown in the following statement of the average and highest weekly produce of crude iron from the Dowlais furnaces in the undermentioned years.*

Year.	No. of Furnaces.	Average make Tons.	Highest make Tons.
1790	2	20	29
1795	3	27	44
1800	3	36	50
1805	3	42	68
1810	4	50	75
1815	4	58	92
1820	7	62	109
1825	11	66	98
1830	11	78	126
1835	13	85	130
1840	17	88	136
1845	18	101	190
1850	18	102	170
1855	18	116	180

* COMPARATIVE WEEKLY MAKE OF BRITISH AND FOREIGN FURNACES.—Mr.

ART. IV.—ON THE MODE OF TESTING BUILDING MATERIALS, AND AN ACCOUNT OF THE MARBLE USED IN THE EXTENSION OF THE UNITED STATES CAPITOL. By PROFESSOR JOSEPH HENRY, Secretary of the Smithsonian Institution.*

A COMMISSION was appointed by the President of the United States, in November, 1851, to examine the marbles which were offered for the extension of the United States Capitol, which consisted of General Totten, A. J. Downing, the Commissioner of Patents, the architect, and myself. Another commission was subsequently appointed, in the early part of the year 1854, to repeat and extend some of the experiments,—the members of which were General Totten, Professor Bache, and myself.

A part of the results of the first commission were given in a report to the Secretary of the Interior, and a detailed account of the whole of the investigations of these committees will ultimately be given in full in a report to Congress, and I propose here merely to present some of the facts of general interest, or which may be of importance to those engaged in similar researches.

Although the art of building has been practised from the earliest times, and constant demands have been made, in every age, for the means of determining the best materials, yet the process of ascertaining the strength and durability of stone appears to have received but little definite scientific attention, and the commission, who have never before made this subject a special object of study, have been surprised with unforeseen difficulties at

Blackwell in his Lecture on the iron-making resources of the United Kingdom, delivered before the Society of Arts in 1852, in speaking of the state of the manufacture in this country, has the following remarkable statement.—"We cannot boast of any exclusive skill in manufacture. In the United States there are now furnaces smelting iron with anthracite coal, and making a weekly produce double or treble that produced by the anthracite furnaces of South Wales."

We are at a loss to conceive Mr. Blackwell's reasons for thus boldly asserting that the British manufacturer was inferior in skill to the American. The average weekly produce of the South Wales anthracite furnace is between 80 and 90 tons; higher makes of 110 to 120 are quite common. From our extensive acquaintance with American works, we can state, that, the capacity of furnace and quality of ores being alike, the produce of the South Wales furnaces is in excess of the American.

We must direct attention to a circumstance of considerable importance in all estimates of produce and quantities. The estimates of the American makes are generally based on the legal ton of 2,240 lbs., but on other occasions their ton is so low as 2,000 lbs. Now the British manufacturer sells at the legal ton of 2,240 lbs.; but in all estimates of production, payments to workmen, &c., the ton of iron is 2,400 lbs.; while that of the coal and ore varies from 2,520 to 2,760 lbs.

* From the Proceedings of the American Association for the advancement of Science, held at Providence, R. I., August, 1855. New York: 1856.

every step of their progress, and have come to the conclusion that the processes usually employed for solving these questions are still in a very unsatisfactory state.

It should be recollected, that the stone in the building is to be exposed for centuries, and that the conclusions desired are to be drawn from results produced in the course of a few weeks. Besides this, in the present state of science, we do not know all the actions to which the materials are subjected in nature, nor can we fully estimate the amount of those which are known.

The solvent power of water, which even attacks glass, must in time produce an appreciable effect on the most solid material, particularly where it contains, as the water of the atmosphere always does, carbonic acid in solution. The attrition of siliceous dusts, when blown against a building, or washed down its sides by rain, is evidently operative in wearing away the surface, though the evanescent portion removed at each time may not be indicated by the nicest balance. An examination of the basin which formerly received the water from the fountain at the western entrance of the Capitol, now deposited in the Patent Office, will convince any one of the great amount of action produced principally by water charged with carbonic acid. Again, every flash of lightning not only generates nitric acid,—which, in solution in the rain, acts on the marble,—but also by its inductive effects at a distance produces chemical changes along the moist wall, which are at the present time beyond our means of estimating. Also the constant variations of temperature from day to day, and even from hour to hour, give rise to molecular motions which must affect the durability of the material of a building. Recent observations on the pendulum have shown that the Bunker Hill Monument is scarcely for a moment in a state of rest, but is constantly warping and bending under the influence of the varying temperature of its different sides.

Moreover, as soon as the polished surface of a building is made rough from any of the causes aforementioned, the seeds of minute lichens and mosses, which are constantly floating in the atmosphere, make it a place of repose, and by the growth and decay of the microscopic plants which spring from these, discoloration is produced, and disintegration is assisted.

But perhaps the greatest source of the wearing away in a climate like ours, is that of the alternations of freezing and thawing which take place during the winter season; and though this effect must be comparatively powerful, yet, in a good marble, it requires the accumulated effect of a number of years in order definitely to estimate its amount. From all these causes, the commission are convinced that the only entirely reliable means of ascertaining the comparative capability of marble to resist the weather, is to study the actual effects of the atmosphere upon it, as exhibited in buildings which for years have been exposed to

these influences. Unfortunately, however, in this country, but few opportunities for applying this test are to be found. It is true some analogous information may be derived from the examination of the exposed surfaces of marble in their out-crops at the quarry; but in this case the length of time they have been exposed, and the changes of action to which they may have been subjected, during, perhaps, long geological periods, are unknown; and since different quarries may not have been exposed to the same action, they do not always afford definite data for reliable comparative estimates of durability, except where different specimens occur in the same quarry.

As we have said before, the art of testing the quality of stone for building purposes is at present in a very imperfect state; the object is to imitate the operations of nature, and at the same time to hasten the effect by increasing the energy of the action, and, after all, the result may be deemed but as approximative, or, to a considerable degree, merely probable.

About twenty years ago an ingenious process was devised by M. Brard, which consists in saturating the stone to be tested with a solution of the sulphate of soda. In drying, this salt crystal lizes and expands, thus producing an exfoliation of surface which is supposed to imitate the effect of frost. Though this process has been much relied on, and generally employed, recent investigations made by Dr. Owen, lead us to doubt its perfect analogy with that of the operations of nature. He found that the results produced by the actual exposure to freezing and thawing in the air, during a portion of the winter, in the case of the more porous stones, produced very different results from those obtained by the drying of the salt. It appears from his experiments, that the action of the latter is chemical as well as mechanical.

The commission, in consideration of this, have attempted to produce results on the stone by freezing and thawing by means of artificial cold and heat. This process is, however, laborious; each specimen must be enclosed in a separate box fitted with a cover, and the amount of exfoliation preduced is so slight, that in good marble the operation requires to be repeated many times before reliable comparative results can be obtained. In prosecuting this part of the inquiries, unforeseen difficulties have occurred in ascertaining precisely the amount of the disintegration, and it has been found that the results are liable to be vitiated by circumstances which were not in view at the commencement of the inquiries.

It would seem at first sight, and the commission when they undertook the investigation were of the same opinion, that but little difficulty would be found in ascertaining the strength of the various specimens of marbles. In this, however, they were in error. The first difficulty which occurred was to procure the proper instrument for the purpose. On examining the account

of that used by Rennie, and described in the Transactions of the Royal Society of London, the commission found that its construction involved too much friction to allow of definite comparative results. Friction itself has to be overcome, as well as the resistance to compression, and since it increases in proportion to the pressure, the stronger stones would appear relatively to withstand too great a compressing force.

The commission first examined an instrument—a hydraulic press—which had previously been used for experiments of this kind, but found that it was liable to the same objection as that of the machine of Rennie. They were, however, extremely fortunate subsequently in obtaining, through the politeness of Commodore Ballard, commandant of the Navy Yard, the use of an admirable instrument devised by Major Wade, late of the United States Army, and constructed under his direction, for the purpose of testing the strength of gun metals. This instrument consists of a compound lever, the several fulcra of which are knife-edges, opposed to hardened steel surfaces. The commission verified the delicacy and accuracy of the indications of this instrument by actual weighing, and found, in accordance with the description of Major Wade, the equilibrium was produced by *one* pound in opposition to *two hundred.* In the use of this instrument the commission were much indebted to the experience and scientific knowledge of Lieutenant Dahlgreen, of the Navy Yard, and to the liberality with which all the appliances of that important public establishment were put at their disposal.

Specimens of the different samples of marble were prepared in the form of cubes of one inch and a half in dimension, and consequently exhibiting a base of two and a quarter square inches. These were dressed by ordinary workmen with the use of a square, and the opposite sides made as nearly parallel as possible by grinding by hand on a flat surface. They were then placed between two thick steel plates, and in order to insure an equality of pressure, independent of any want of perfect parallelism and flatness on the two opposite surfaces, a thin plate of lead was interposed above and below between the stone and the plates of steel. This was in accordance with a plan adopted by Rennie, and that which appears to have been used by most, if not all, of the subsequent experimenters in researches of this kind. Some doubt, however, was expressed as to the action of interposed lead, which induced a series of experiments to settle this question, when the remarkable fact was discovered, that the yielding and approximate equable pressure of the lead caused the stone to give away at about half the pressure it would sustain without such an interposition. For example, one of the cubes, precisely similar to another which withstood a pressure of upwards of 60,000 pounds when placed in immediate contact with the steel plates, gave way at about 30,000 with lead interposed.

This remarkable fact was verified in a series of experiments, embracing samples of nearly all the marbles under trial, and in no case did a single exception occur to vary the result.

The explanation of this remarkable phenomenon, now that it is known, is not difficult. The stone tends to give way by bulging out in the centre of each of its four perpendicular faces, and to form two pyramidal figures, with their apices opposed to each other at the centre of the cube, and their bases against the steel plates. In the case where rigid equable pressure is employed, as in that of the thick steel plate, all parts must give way together. But in that of a *yielding* equable pressure, as in the case of interposed lead, the stone first gives way along the lines of least resistance, and the remaining pressure must be sustained by the central portions around the vertical axis of the cube.

After this important fact was clearly determined, lead and all other interposed substances were discarded, and a method devised by which the upper and lower surfaces of the cube could be ground into perfect parallelism. This consists in the use of a rectangular iron frame, into which a row of six of the specimens could be fastened by a screw at the end. The upper and lower surfaces of this iron frame were wrought into perfect parallelism by the operation of a planing machine. The stones being fastened into this, with a small portion of the upper and lower parts projecting, the whole were ground down to a flat surface, until the iron and the face of the cubes were thus brought into a continuous plane. The frame was then turned over, and the opposite surfaces ground in like manner. Care was of course taken that the surfaces thus reduced to perfect parallelism, in order to receive the action of the machine, were parallel to the natural beds of the stone.

All the specimens tested were subjected to this process, and in their exposure to pressure were found to give concordant results. The crushing force exhibited in the subjoined table is much greater than that heretofore given for the same material.

The commission have also determined the specific gravities of the different samples submitted to their examination, and also the quantity of water which each absorbs.

They consider these determinations, and particularly that of the resistance to crushing, tests of much importance, as indicating the cohesive force of the particles of the stone, and its capacity to resist most of the influences before mentioned.

The amount of water absorbed may be regarded as a measure of the antagonistic force to cohesion, which tends, in the expansion of freezing, to disintegrate the surface. In considering, however, the indication of this test, care must be taken to make the comparison between marbles of nearly the same texture, because a coarsely crystallized stone may apparently absorb a small quantity of water, while in reality the cement which unites the

crystals of the same stone may absorb a much larger quantity. That this may be so was clearly established in the experiments with the coarsely crystallized marbles examined by the commission. When these were submitted to a liquid which slightly tinged the stone, the coloration was more intense around the margin of each crystal, indicating a greater amount of absorption in these portions of the surface.

The marble which was chosen for the Capitol is a dolomite, or is composed of carbonate of lime and magnesia in nearly atomic proportions. It was analyzed by Dr. Torrey of New York, and Dr. Genth of Philadelphia. According to the analysis of the former, it consists, in hundredth parts, of

Carbonate of lime,	54·621
Carbonate of magnesia,	43·932
Carbonate of protoxide of iron,	·365
Carbonate of protoxide of manganese,	(a trace)
Mica,	·472
Water and loss,	·610

The marble is obtained from a quarry in the southeasterly part of the town of Lee, in the State of Massachusetts, and belongs to the great deposit of primitive limestone which abounds in that part of the district. It is generally white, with occasional blue veins. The structure is fine-grained. Under the microscope it exhibits fine crystals of colorless mica, and occasionally also small particles of bisulphuret of iron. Its specific gravity is 2·8620; its weight 178·87 lbs. per cubic foot. It absorbs ·103 parts of an ounce per cubic inch, and its porosity is great in proportion to its power of resistance to pressure. It sustains 23,917 lbs. to the square inch. It not only absorbs water by capillary attraction, but, in common with other marbles, suffers the diffusion of gases to take place through its substance. Dr. Torrey found that hydrogen and other gases, separated from each other by slices of the mineral, diffuse themselves with considerable rapidity through the partition.

This marble, soon after the workmen commenced placing it in the walls, exhibited a discoloration of a brownish hue, no trace of which appeared so long as the blocks remained exposed to the air in the stone-cutter's yard. A variety of suggestions and experiments were made in regard to the cause of this remarkable phenomenon, and it was finally concluded that it was due to the previous absorption by the marble of water holding in solution a small portion of organic matter, together with the absorption of another portion of water from the mortar.

To illustrate the process, let us suppose a fine capillary tube, the lower end of it immersed in water, and of which the internal diameter is sufficiently small to allow the liquid to rise to the top, and be exposed to the atmosphere; evaporation will take place at the upper surface of the column, a new portion of water will

be drawn in to supply the loss; and if this process be continued, any material which may be dissolved in the water, or mechanically mixed with it, will be found deposited at the upper orifice of the tube, or at the point of evaporation.

If, however, the lower portion of the tube be not furnished with a supply of water, the evaporation at the top will not take place, and the deposition of foreign matter will not be exhibited, even though the tube itself may be filled with water impregnated with impurities. The pores of the stones so long as the blocks remain in the yard, are in the condition of the tube not supplied at its lower end with water, and consequently no current takes place through them, and the amount of evaporation is comparatively small; but when the same blocks are placed in the wall of the building, the absorbed water from the mortar at the interior surface gives us the supply of the liquid necessary to carry the coloring material to the exterior surface, and deposit it at the outer orifices of the pores.

The cause of the phenomenon being known, a remedy was readily suggested, which consisted in covering the surface of the stone to be imbedded in mortar with a coating of asphaltum. This remedy has apparently proved successful. The discoloration is gradually disappearing, and in time will probably be entirely imperceptible.

This marble, with many other specimens, was submitted to the freezing process fifty times in succession. It generally remained in the freezing mixture for twenty-four hours, but sometimes was frozen twice in the same day. The quantity of material lost was ·00315 parts of an ounce. On these data Captain Meigs has founded an interesting calculation, which consists in determining the depth to which the exfoliation extended below the surface as the effect of its having been frozen fifty times. He found this to be very nearly the ten-thousandth part of an inch. Now, if we allow the alternations of freezing and thawing in a year on an average to be fifty times each, which, in this latitude, would be a liberal one, it would require ten thousand years for the surface of the marble to be exfoliated to the depth of one inch. This fact may be interesting to the geologist as well as the builder.

Quite a number of different varieties of marble were experimented upon. A full statement of the result of each will be given in the reports of the committees.

At the meeting of the Association at Cleveland, I made a communication on the subject of *cohesion.* The paper, however, was presented at the last hour; the facts were not fully stated, and have never been published. I will, therefore, occupy your time in briefly presenting some of the facts I then intended to communicate, and which I have since verified by further experiments and observations.

In a series of experiments made some ten years ago, I showed that the attraction for each other of the particles of a substance in a liquid form was as great as that of the same substance in a solid form. Consequently, the distinction between liquidity and solidity does not consist in a difference in the attractive power occasioned directly by the repulsion of heat; but it depends upon the perfect mobility of the atoms, or a lateral cohesion. We may explain this by assuming an incipient crytsallization of atoms into molecules, and consider the first effect of heat as that of breaking down these crystals, and permitting each atom to move freely around every other. When this crystalline arrangement is perfect, and no lateral motion is allowed in the atoms, the body may be denominated perfectly rigid. We have approximately an example of this in cast-steel, in which no slipping takes place of the parts on each other, or no material elongation of the mass; and when a rupture is produced by a tensile force, a rod of this material is broken with a transverse fracture of the same size as that of the original section of the bar. In this case every atom is separated at once from the other, and the breaking weight may be considered as a measure of the attraction of cohesion of the atoms of the metal.

The effect, however, is quite different when we attempt to pull apart a rod of lead. The atoms or molecules slip upon each other. The rod is increased in length, and diminished in thickness, until a separation is produced. Instead of lead, we may use still softer materials, such as wax, puty, &c., until at length we arrive at a substance in a liquid form. This will stand at the extremity of the scale, and between extreme rigidity on the one hand, and extreme liquidity on the other, we may find a series of substances gradually shading from one extremity to the other.

According to the views I have presented, the difference in the tenacity in steel and lead does not consist in the attractive cohesion of the atoms, but in the capability of slipping upon each other. From this view, it follows that the form of the material ought to have some effect upon its tenacity, and also that the strength of the article should depend in some degree upon the process to which it had been subjected.

For example, I have found that softer substances, in which the outer atoms have freedom of motion, while the inner ones by the pressure of those exterior are more confined, break unequally; the inner fibres, if I may so call the rows of atoms, give way first, and entirely separate, while the exterior fibres show but little indications of a change of this kind.

If a cylindrical rod of lead three quarters of an inch in diameter be turned down on a lathe in one part to about half an inch, and then be gradually broken by a force exerted in the direction of its length, it will exhibit a cylindrical hollow along its axis of

half an inch in length, and at least a tenth of an inch in diameter. With substances of greater rigidity this effect is less apparent, but it exists even in iron, and the interior fibres of a rod of this metal may be entirely separated, while the outer surface presents no appearance of change.

From this it would appear that metals should never be elongated by mere stretching, but in all cases by the process of wire-drawing, or rolling. A wire or bar must always be weakened by a force which permanently increases its length without at the same time compressing it.

Another effect of the lateral motion of the atoms of a soft heavy body, when acted upon by a percussive force with a hammer of small dimensions in comparison with the mass of metal,—for example, if a large shaft of iron be hammered with an ordinary sledge,—is a tendency to expand the surface so as to make it separate from the middle portions. The interior of the mass by its own inertia becomes as it were an anvil, between which and the hammer the exterior portions are stretched longitudinally and transversely. I here exhibit to the Association a piece of iron originally from a square bar four feet long, which has been so hammered as to produce a perforation of the whole length entirely through the axis. The bar could be seen through, as if it were the tube of a telescope.

This fact appears to me to be of great importance in a practical point of view, and may be connected with many of the lamentable accidents which have occurred in the breaking of the axles of locomotive engines. These, in all cases, ought to be formed by *rolling*, and not with the hammer.

The whole subject of the molecular constitution of matter offers a rich field for investigation, and isolated facts, which are familiar to almost every one when attentively studied, will be made to yield results alike interesting to abstract science and practical art.

Art. VI.—ON THE OCCURRENCE OF THE ORES OF IRON IN THE AZOIC SYSTEM.—By J. D. Whitney.*

The object of the present communication is to call attention to the geological position and mode of occurrence of one of the most interesting and important classes of the ores of iron, namely, those which are associated with rocks of the Azoic System.

The term Azoic, first employed by Murchison and De Ver-

* Proceedings of the American Association for the Advancement of Science, Ninth Meeting, held at Providence, R. I., August, 1855, p. 209.

neuil in their description of the geology of the Scandinavian Peninsula, has been adopted by Mr. Foster and myself in our Reports on the Geology of the Lake Superior Land District, and has been shown by us to be applied with propriety to a series of rocks which cover an immense space in the Northwest. We have called attention to the fact, that this system of rocks, wherever it has been demonstrated to exist, has been found characterized by the presence of deposits of ores of iron, developed on a scale of magnitude beyond anything which occurs in any of the succeeding geological groups or systems of rocks.

In illustration of these views, we have briefly described some of the great ferriferous districts of the world, and particularly those of Lake Superior, Scandinavia, Missouri, and Northern New York, all of which exhibit a most marked analogy with each other, both in regard to the mode of occurrence and the geological position of the ores. The two last-named regions, however, not having been thoroughly examined by us in person, we were obliged to content ourselves with information obtained from others, in making a comparison of their most striking features.

Strongly impressed with the interest attaching to this subject, I availed myself of the first opportunity, after the publication of our Report, to visit the iron regions of Missouri and Northern New York, from the last-named of which I have just returned, after a careful examination of the most important localities where ore is now mined in that district. While it is intended to take another opportunity for giving a minute and detailed account of this region, I may be permitted to recapitulate here the principal points maintained by Mr. Foster and myself, to the general correctness of which my more recent explorations have furnished me with additional evidence.

We maintain therefore,—

1. That deposits of the ores of iron exist in various parts of the world, which in extent and magnitude are so extraordinary as to form a class by themselves. The iron regions mentioned above, offer the most striking examples of the deposits now referred to.

2. That the ores thus occurring have the same general character, both mineralogically and in their mode of occurrence, or their relations of position to the adjacent rocks.

3. That these deposits all belong to one geological position, and are characteristic of it.

The extent of the workable deposits of the ores of the useful metals is usually quite limited. Most of the veins which are wrought in mines throughout the world are but a few feet in width, often not more that a few inches. This is true of the ores occurring in veins. In sedimentary metalliferous deposits, such as those of the ores of iron in the carboniferous, the horizontal

extent is often very considerable; but the vertical range is so limited, that the most extensive basins may be in time exhausted, when worked on so extensive a scale as is the case in some of the celebrated iron districts of Great Britain. The deposits of iron in the azoic, however, are many of them developed on a scale of such magnitude, that the term "mountain masses" may be applied to them without exaggeration, while, from the very nature of their occurrence, they must extend indefinitely downwards, and cannot be exhausted. Thus the great iron mountain of Gellivara, in Sweden, has a length of three or four miles, and a width of not less than a mile and a half. Of course such a mass of ore, without limit in depth, might be worked on the most enlarged scale for any length of time without fear of exhaustion. The same may be said of some of the iron knobs and ridges of Lake Superior and of Missouri. They form veritable mountains of ore, and ages must elapse before their dimensions will have been perceptibly diminished. This is not necessarily the case with all the localities of ore of these districts. Indeed, in Northern New York and in Scandinavia, although there are accumulations of iron which may be measured by hundreds of feet, or even by miles, yet those which are best known and most worked are of much more reasonable dimensions.

The character of the ores thus occurring is mineralogically peculiar. They consist uniformly of the oxides, either the magnetic or the specular. Hydrous ores, carbonates and the like, are altogether wanting, unless it be upon the borders of the ore deposits, where a secondary metamorphic action between the ferriferous mass and the adjacent rocks may have taken place. The oxides found in this geological position are in general remarkably free from all injurious substances, such as sulphur, arsenic, lead, or zinc, and usually the approach to chemical purity in the ores is in proportion to the extent of the mass, the largest deposits being the purest. The principal foreign ingredient mixed with these ores is silica, which is always present, although frequently in minute quantity. Indeed, the analyses of the Lake Superior and Missouri ores show, in some instances, a surprisingly near approach to a state of absolute purity. It would not be difficult in some localities to procure large quantities of an ore not containing more than two or three tenths of one per cent. of foreign matter, and that exclusively silica. The purity of the ores may be inferred from the high character and value of the iron manufactured from them when they have been skilfully worked, as, for instance, in Sweden. Some samples of iron manufactured from Lake Superior ore have, when tested, exhibited a degree of tenacity unequalled by that from any other part of the world. The ores of Lake Superior and Missouri are mostly peroxides; those of Northern New York almost exclusively magnetic; while in Scandinavia the magnetic and specular ores are both of

frequent occurrence. Those of New York are often coarse-grained and highly crystalline, while the peroxides of Lake Superior and Missouri are rarely distinctly crystallized, but are very compact.

The mode of occurrence of these ores in the regions above mentioned is so peculiar, that, from this point of view alone, it is apparent that these deposits should be classed together as distinct from those in the later geological formations. In all the characteristics of true veins, the great masses of ore now under consideration are wholly wanting. Some of the least important of them approach much nearer to segregated veins; and might with propriety be classed with them, were they not developed on so large a scale as to render it difficult to conceive of segregation as a sufficient cause for their production.

In the case of the most prominent masses of ore of these regions there is but one hypothesis which will explain their vast extent and peculiar character. They are simply parts of the rocky crust of the earth, and, like other igneous rocks, have been poured forth from the interior in the molten or plastic state. No other origin can be assigned to the dome-shaped and conical masses of Lake Superior and Missouri, or to the elongated ridges of the first-named region. The Iron Mountain of Missouri forms a flattened dome-shaped elevation, whose base covers a surface of a little less than a square mile, and which rises to a height of 200 feet above the general level of the adjacent country. The surface of the mountain, where bare of soil, is found to be covered with loose blocks of peroxide of iron, without any admixture of rocky pebbles or fragments, which increase in size in ascending to the summit, where large blocks of ore many tons in weight lie scattered about, and piled upon each other. It is a most singular fact, that the ore is nowhere seen in place about the mountain, although the whole mass evidently consists of nothing else. Near its base, an excavation of seventeen feet deep has been made, which exhibits nothing but small, somewhat rounded fragments of ore closely compacted together, without any other substance present except a little red, ferruginous clay, which seems to have been formed by the friction of the masses against each other. This feature in the Iron Mountain is one of peculiar interest, and one which it seems difficult to explain. Evidences of drift action in this region are exceedingly faint. The ore itself is one which seems little likely to undergo decomposition from any exposure to atmospheric changes. The blocks upon the summit, although somewhat moss-grown, have their angles and edges but little rounded. As a key to the origin of the ore, we find in close proximity on the north a long elevation of a reddish porphyry of unmistakably eruptive character, connected with the Iron Mountain by a narrow ridge of a rock composed of iron ore and feldspathic rock, showing that the

porphyritic ridge and the ore-mass must have originated at one and the same time, and in the same way.

The eruptive origin of the great Lake Superior ore-masses seems also well sustained by the phenomena which they exhibit. They alternate with trappean ridges whose eruptive origin cannot be doubted, and which, themselves, contain so much magnetic oxide disseminated through their mass, as one of their essential ingredients, that they might almost be called ores. These eruptive masses include the largest and purest deposits of ore which are known in the Lake Superior or the Missouri iron regions; but there are other localities in both these districts where the mode of occurrence of the ore is somewhat different, and where the evidences of a direct igneous origin are less marked. This class comprehends those lenticular masses of ore which are usually included within gneissoidal rocks, and whose dip and strike coincide with that of the gneiss itself, but whose dimensions are limited. Such is the character of most of the Swedish deposits, and of many of those of Northern New York. Such beds of ore as these may in some cases be the result of segregating action; but the facts seem rather to indicate that they are made up of the ruins of pre-existing igneous masses, which have been broken and worn down, during the turbulent action which we may suppose to have been pre-eminently manifested during the azoic epoch, and then swept away by currents, and deposited in the depressions of the sedimentary strata in process of formation. In confirmation of this hypothesis in regard to the origin of these lenticular masses of ore in the gneissoidal rocks, it may be noticed that the ores occurring in this form and position are less pure than those of decidedly igneous origin, as if they had become more or less mixed with sand during the process of reconstruction, so that they not unfrequently require to be separated from their earthy impurities by washing before they can be advantageously used. Again, it may be observed in the case of some of the ore-beds of this class, that the bed-rock or foot-wall is considerably rougher or more irregular in its outline than the hanging wall or roof, as if depositions had taken place upon a surface originally rough and uneven, the upper surface of the ore being considerably smoother and more regular than the lower one, and sometimes separated from the rock above by a thin seam of calcareous matter.

There is still another form of deposit which is not unfrequently met with in the Lake Superior region, and which may be seen on a grand scale in the Pilot Knob of Missouri. This consists of a series of quartzose beds of great thickness, and passing gradually into specular iron, which frequently forms bands of nearly pure ore, alternating with bands of quartz more or less mixed with the same substance. Some of the deposits in the Lake Superior region are of this class, and they are very

extensive, and capable of furnishing a vast amount of ore, although most of it is so mixed with silicious matter, as to require separating by washing, before use. Heavy beds of nearly pure ore occur at the Pilot Knob, interstratified with beds of a poorer quality. Deposits of this character are usually very distinctly bedded, and the ore shows a greater tendency to cleave into thin laminæ parallel with the bedding, in proportion to its freedom from silicious matter. These deposits seem to have been of sedimentary origin, having been originally strata of silicious sand, which has since been metamorphosed. The iron ore may have been introduced either by the sublimation of metalliferous vapors from below during the deposition of the silicious particles, or by precipitation from a ferriferous solution, in which the stratified rocks were in process of formation.

The great deposits of ore which have been alluded to above, agreeing as they do in the characteristic features of their mode of occurrence, especially in the magnitude of the scale on which they are developed, are all, beyond doubt, situated in the same geological position; they all belong to the oldest known system of rocks, the azoic. This name was first applied by Murchison to the ferriferous rocks of Scandinavia, and the geological position of the great iron regions of this country is precisely similar to those of Sweden. There is ample evidence that the lowest known fossiliferous strata, characterized by the same peculiar types of organic life, both in this country and in Europe, rest uniformly upon the iron-bearing strata throughout the Northwest, from New York to Missouri and Arkansas.

We have thus seen that the earliest geological epoch was characterized by the presence of the ores of iron in quantity far exceeding that of any succeeding one; indeed, we may infer that the ruins of the iron ores of this class have furnished the material from which many of the ores of more recent geological age may have been derived. The condition of things in reference to the ores of iron which existed during the azoic period underwent a complete change, and rarely do we find in any fossiliferous rocks any signs of unmistakably eruptive ores. It is certain that we nowhere, out of the azoic system, find masses of ore of such extent and purity as those which have just been alluded to. By far the larger portion of the azoic series on the earth's surface being covered up by the fossiliferous rocks, the ore which that formation contains is equally concealed, and it is only in those regions where no deposition of newer strata upon the oldest rocks has taken place that the treasures of iron are made accessible. In this respect our country is pre-eminently favored, and there can be no doubt that the immense deposits of iron ore stowed away in the Northwest, are destined at some future time to add to our national wealth more than has been or ever will be contributed by the gold of California. It may seem absurd to speculate on

the exhaustion of the stratified ores of England or of the Eastern United States; yet nothing is more certain, than that the present rate of production in the former country cannot be kept up for any very great length of time, without making the cost of procuring ore so great, that other regions which now seem very remote from a market will be able to compete with the most favored iron-producing districts of England.

Practically, the views which have been presented above are of importance, as leading us to expect large and valuable deposits of the ores of iron wherever the azoic rocks are found to exist over any considerable surface. Thus it may safely be predicted that important discoveries of ore will be made, in the now almost unexplored regions of British America, which are covered by rocks of the azoic period. Indeed, large beds of ore have already been found in Canada, which are, in character and position, analogous to those of Northern New York.

Art. VII.—THE MINING OF COAL, &c., &c. By A. T. Ponson. No. 5.

[Continued from page 331, Vol. VI.]

36. *External figure of the coal deposits.*

The carboniferous strata and the incumbent rocks are not broken by mountains and hills of steep and sharp descent, or by deep and narrow valleys. On the contrary, these formations present to view only plateaus, or vast plains through which some streams flow, or simply groups of rounded hills of a moderate height.

Immediately after the convulsions which rent the crust of the globe, after the folding and rupture of the strata, the coal series probably presented on the surface vast fissures and abrupt precipices; the summits extended to sharp peaks, such as are frequently met with in the midst of formations composed of rocks which are very hard and little affected by atmospheric influences.

But the seams and the enclosing rocks, being usually of a tender and brittle nature, have not been able to preserve their irregularities; and yielding to the erosive action of water, they have been speedily reduced to a level—their masses being made round, the hills washed down, and carried and deposited in the adjacent cavities. The same result is presented where the coal strata is found covered by more recent formations; those stratified in beds sensibly horizontal, and rarely affected by dislocations, have not become uneven in surface only in consequence of the irregularities of the deposition, or in consequence of currents of

water, which, furrowing the surface, have caused the gentle slopes of plains and hills.*

It results from the preceding remarks, that the slopes of the surface are not necessarily in conformity with the inclination of the beds; or, at least, that the irregularities of the actual surface should be the result of the inclinations and faults of the coal strata, is a very rare circumstance. Thus, to indicate or determine the bearing of seams in conformity to the unevenness of the surface, and its external configuration, is a useless speculation; and the opinion of miners, who having discovered an accidental parallelism between the inclination of the slopes of valleys and the seams of coal, have thence inferred a general rule, is erroneous to such a degree, that the exceptions are probably more numerous than the cases to which the rule applies. It often happens, if one regards the bearing of seams in a general manner, that their direction is parallel to the great axis of the basins, and this axis is confounded with that of the valleys.

37. *Origin of the water encountered by the miner when penetrating the earth.*

At different depths beneath the surface the miner meets with water in greater or less quantities, according to the disposition of the layers and the structure of the strata. It is now well proved, although a different opinion was at one time entertained, that all comes from the surface, where it has been absorbed by the different strata cropping beneath the vegetable soil. The rains which do not flow off to form streams and rivers, are infiltrated through the beds of the strata, the pores, joints, and fissures of which they traverse, descending until they meet a strata which is devoid of the properties of filtration, where they are arrested and retained. If the plane of a stratification of a bed is such that its lowest part outcrops upon the side of a hill, or if it is entirely above the bottom of a valley, the waters flow off naturally; but if the impermeable bed folds and forms a basin, without an outlet, the water accumulates in a quantity dependent upon the porosity of the rock and the number and capacity of the fissures, thus forming simple internal springs, or vast sheets ready to drain into the shafts or other cavities which present a diminished lateral resistance. If, unfortunately, the layers which have been penetrated by an excavation have an outcrop in the bed of a little pond or

* It should be remembered that the superincumbent strata composed of rock of sufficient hardness to resist the action of the atmosphere, although they do not form actual mountains, yet present, always very elevated summits, having steep sides, and peaks even 150 to 200 feet in height. We find likewise the surface of the carboniferou sstrata ragged and broken by trap and other volcanic matters, filling certain fissures, and elevated above the surface in consequence of the destruction of the rocks enclosing coal.

river, or rivulet, the copious and constant infiltrations bring into the mine great volumes of water, of which the miner is oftentimes unable to rid himself. All the considerations apply with equal force to the coal series and the stratifications incumbent upon them.

38. *State of the waters in the chalk series.*

The dead grounds are dry, or carry water according to their position relative the bottom of the valleys, in which the surface is broken, that is to say, according as they are placed above or below the natural water level; the relative situation of the strata and the inflections to which they are often subjected, create oftentimes modifications in the general system that controls the waters.

The permeable beds of the chalk formations are traversed in every way by innumerable fissures, or straight cracks, which are horizontal or inclined, and communicating together and resembling in the mass, vast reservoirs, into which the rains settle. This water, unable to penetrate the *dieves* usually covering the coal strata where it collects, or to expand itself upon a horizontal ground, rises upward, and attains a level in the bottom of adjacent valleys, where it finds a free course. The upper portion can then be drained, but the lower is divided into as many cavities as there are fractured or permeable strata contained between the two beds of impenetrable clay. This is the cause of the gushing up of artesian springs which the miner encounters in the midst of the layers of the chalk formation, and which rise in the excavations towards the surface of the ground. The springs contained in this strata are called *niveaux*. To penetrate these water-bearing layers and to restrain the water from entering the excavation, is called passing a *niveau*.

The abundance of the springs flowing in the cavities is a cause of the greater or less resistance they encounter in passing from one point to another; so likewise the number and the extent of the fractures containing them. Thus, where these are rare, slightly open, and such that they present serious obstacles to the circulation of the water, a simple windlass is sufficient to draw it off. But where the fractures are numerous, and extend a great distance, the collection of water is great, and its drainage at any one point is perceived in all the adjacent shafts. If, in short, any fissure open into a rivulet, the drainage becomes impracticable.

Fissures are very irregularly scattered in the mass of the chalk strata. We hear of cases in which the miner, after having long contended against the obstacles presented by the abundance of the springs, has abandoned his labor only to recommence it again at a short distance from the same spot, where the water being less in quantity has not prevented him from triumphing over every obstacle.

It might seem, at first view, that a coal formation completely

exposed, might be very advantageous, since the labor of exploring is simple and expensive, nor does the water present any obstacle to the openings required for obtaining the coal. Nevertheless, when the covering strata contain in their lower portion impermeable stratifications like the *dieves*, especially when they are not too thick or carry too much water, the difficulties of sinking are largely compensated by the advantage that the miner is protected from a large portion of the water at the base of the chalk series, during all the period of this operation, however long that may be.

39. *Of the waters in the coal strata.*

The miner has no reason to apprehend in the coal strata any abundant springs, like those in the chalk formation. The beds of schist and the seams of coal furnish some rare infiltrations, which appear under the form of little streams or droppings escaping from the pores of the rock. But the sandstone, usually much fractured, and the clefts of which are very open, offers a passage to the water, very difficult to restrain and costly to drain. In general, the rule, or nature, of springs seems to be subject to one or the other of the following conditions; sometimes they dry up, after having been reduced by drainage, and do not appear again, or at least they do not show themselves again, except in very small quantity and at periods noted for heavy rains; sometimes they continue to discharge water with great uniformity; when such is the case, it is caused by some fissure operating as a canal from a great reservoir to the shaft, and furnishing the constant supply. In short, the waters of mines are generally more abundant the nearer the working approaches the surface, because the nearer they are to their source, so much less are the obstacles encountered by them in passing through the fissures of the strata.*

To be continued.

* A series of chapters more immediately follows in the works of Ponson which are devoted to descriptions of the coal basins of Belgium, France, England, and Germany. As these are particulars not of immediate interest to the practical miner in this country, we propose to pass over them for the present, and commence next with "The method of searching for coal."—Ed.

COALS AND COLLIERIES.

ANTHRACITE COAL TRADE FOR 1856.

Shipments by Reading Railroad to August 21st,	1,378,589 08	tons.
" Schuylkill Canal,	640,824 00	"
	2,019,418 08	"
Same time last year,	2,179591 08	"
Decrease in 1856,	160,178 00	"

LEHIGH COAL TRADE TO AUGUST 16, BY CANAL.

Summit Mines,	172,672 07	tons.
Room Run Mines,	87,075 04	"
East Lehigh Mines,	17,152 08	"
A. Lathrop's Pea Coal,	1,197 07	"
Spring Mountain Mines,	56,742 12	"
East Sugar Loaf Mines,	41,680 15	"
Colerain,	40,313 05	"
Stafford,	8,128 16	"
N. Y. Lehigh Coal Co.,	22,994 15	"
German Pennsylvania Coal Co.,	14,444 08	"
South Spring Mountain Ridge,	10,474 10	"
Hazleton Coal Co.,	71,179 07	"
Cranberry Mines,	40,808 18	"
Diamond Mines,	23,833 11	"
Council Ridge,	25,226 10	"
Buck Mountain Co.,	56,508 16	"
Wilkesbarre Coal Co.,	14,598 18	"
Wyoming Coal,	5,606 06	"
Hartford Coal Co,	4,015 08	"
Total,	664,143 01	"

Lehigh Valley Railroad.

Wm. Milnes & Co.,	51,259 15	tons.
Ratcliff & Johnsons,	2,288 08	"
Packer, Carter & Co.,	16,908 14	"
N. Y. & Lehigh,	6,590 11	"
Sharpe, Leisenring & Co.,	8,812 14	"
German Penna. Coal Co.,	2,437 12	"
Total,	82,742 14	"
By Canal,	664,143 01	"
Total for the week,	746,885 15	"
Same time last year, (Canal)	729,063 09	"
Increase in 1856, so far,	17,822 06	"
The decrease by Canal is	64,920 00	"

Delaware and Hudson Co.'s Coal Trade.

For the last week,	271,01	tons.
To same time last year,	322,049	"
Decrease so far,	51,048	"

Pennsylvania Coal Co.'s Coal Trade.

For the last week,	312,186	tons.
To same time last year,	301,339	"
Increase so far,	11,847	"

Scranton Coal Trade for June.

East towards New York,	7,443 17	tons.
West " "	13,212 19	"
Total,	20,656 16	"

The Scranton coal trade east towards New York, for July and to August 23d, will exceed 25,000 tons.

CUMBERLAND COAL TRADE.

Total shipped by each company from Januaray 1st to August 23d.

Cumberland Coal and Iron Co.	196,955.14
Percy & Co.	6,912.13
Aetna Coal Co.	7,521.14
Frostburg Coal Co.	
Borden Mining Co.	
Allegany Mining Co.	106,056.00
Carbon Hill Coal Co.	
Wellersburg Coal Co.	
George's Creek Coal Co.	60,064.08
Swanton Coal Co.	26,100.12
American Coal Co.	35,564.16
Franklin Coal Co.	18,699.07
Lonaconing Coal Co.	16,809.05
Hampshire Coal Co.	19,816.07
Total,	428,470.17

INCREASE OF ANTHRACITE TRADE.

The increase of anthracite thrown into the market for the last five years reached 3,196,443, tons; 5 divided into this, would give the annual increase 630,286 tons. During two of these five years, the markets were completely cleaned out of coal, and prices ruled very high. For the last five years the increase of bituminous and semi-anthracite, including the foreign importations, destined for the Atlantic markets, reached 601,538 tons, which divided by 5 gives the annual increase at 138,307 tons.—*Pottsville Jour.*

COAL WHARVES AT TRENTON, N. J.

The method of unloading cars of coal by shutes into vessels is adopted in many places, varying only in such details as arise from local peculiarities. Those of our readers who have never witnessed this operation, will find the following sketch of the wharves at Trenton, of interest.

The Belvidere, Delaware Railroad crosses the Delaware and Raritan Canal, in the outskirts of the city of Trenton by a drawbridge, and curving towards New York, reaches the coal wharves with three tracks in about half a mile.

A basin is dug or obtained by widening on the berne side of the canal. This basin is now 1,200 feet long, is well wharfed in front, and wide enough for a light schooner to turn around clear of one that may be loading at the time.

The landing to receive the loaded coal cars consists of a heavy and well braced *trestling* parallel with the canal, and carrying mainly three tracks of rails—the deck of the landing being elevated 17 feet above water line, which being in a canal level, has the advantage of being *invariable.*

The play of the landing is the *continuous packet system* (with some stretches of flat floor dumping ground). The *trestles*, are 12 feet apart centres, and between each pair is a sloping pocket crossing *three tracks*, and open to dumpage from each. All these pockets terminate below in a schute with a wrought iron apron, managed by a winch on deck, and proceeded by a cast-iron screen, exactly like the Navigation Landings at Port Carbon, in the dirt-separating arrangement. From these pockets, the coal flows by *gravity*, into vessels.

Each pocket is estimated to contain about 50 tons of coal (or 400 tons

per 100 feet lineal of wharf), *and in their ordinary work 200 tons per hour are loaded from them.*

The aggregate wharf expenses are estimated at 4 to 5 cents per ton loaded, and the whole of the small screenings thus far, commands $1 50 per ton at the wharves, for a New York market.

The loaded cars are placed on the elevated deck of the landing by the following operation:—Up to within a quarter mile of the wharves, the tracks are level with the canal bank, then this quarter mile ascends by a single track on an incline (chiefly on trestling) at 1 in 50 or thereabouts, and the locomotive pushers employed, come up to this incline under headway gained on the level track, and with their cars before them, rush up the ascent, and place their loaded cars upon the deck tracks rapidly and without difficulty. The pusher working to-day, handled with ease 7 loaded cars, containing 35 tons of coal, at once, and she only had the adhesion of *one pair* of drivers. The large engines push up 100 tons of coal at once.

The depth of available draught water in the canal, is 6½ feet. *At present, barges* load at these wharves with 300 tons of coal, and *schooners* for Providence and Boston, load with 200 tons.

All the coal handled here at present is Lehigh Coal, costing for transportation from Mauch Chunk and delivery on the wharves $2 00 per ton.

No difficulty whatever arises from the coal cars having wide treads upon the wheels, and working over *both gauges* of 4 feet 8½ inches and of 4 feet 15 inches.

They are now shipping at their wharves *about* 2,500 *tons a week*, though this is very far within their capacity.

Boats and schooners loading here have about 25 cents a ton advantage in tolls over Richmond. The wharves admit of indefinite extension, and Trenton cannot fail to become a great coal mart, which can only be reached from Schuylkill County by the Allentown Railroad.

The general plan of these wharves and their continuous pockets, are almost a precise duplication of the Dauphin Coal wharves, designed and built by the late Mr. Morton, Civil Engineer, about ten years ago, at Dauphin, on the Susquehanna River.

The switches of the railroad, about here, have the fixed cast-iron guard of the Reading Railroad *attached to the movable rail*, so as to secure a train from leaving the track, in all positions of the switch rail.

The frogs are short, movable rails thrown by a switch lever.

Some of the tracks have "*Trimble's wooden splice*" outside of the joint, well secured to sills and rails, but they do not appear to be very successful, though properly applied.

MAN MACHINES.

This is the name given, in some parts of Europe, to the machinery which is used to raise the miners from the pits, in order to avoid the tedious ascent by ladders. The improvements in the various methods used for ascending and descending shafts, especially in coal mines, was very completely illustrated at the late French Exhibition. This information is too valuable to be lost, and we have collected it from some graphic letters of a correspondent of the Pottsville Journal, who was in Paris during the Exhibition. The latest improvements in use in European collieries are therein described:

In machinery connected with this department France leads off; following close upon her is *Belgium*. The praises and prizes with which imperial societies, in the first country, reward any successful inventions whose object is to render human life more safe, to prevent accidents, to ward off bodily injury from those poor (but not, in France, uncared for) classes, whose every-

day business would seem to expose them to a risk equal to that encountered by the soldier who enlists for battle—have stimulated, to a wonderful extent, ingenuity having this for its object. Accordingly, we find no less than three machines for preventing that most fertile source of accident, the fall of the cages in the pits, from the breaking of the rope or chain by which they are raised and lowered.

The fall of the cages (with the workmen in them) is prevented by a most ingenious contrivance, which, like the safety-lamp and other great humanitarian inventions, is as remarkable for its simplicity as its efficacy. Whoever it be to whom the credit of this idea is to be given (I believe it is M. Machecourt, mining engineer at Decize collieries), he certainly deserves honor, second only to that of Sir Humphrey Davy, for the origination of so benevolent and effectual a plan for removing the terrors from this portion of the miner's daily risks, and rendering a ride up and down the shaft of a colliery as sure and pleasant as an ordinary one in a stage coach or a "Hansom Safety," above ground.

Accidents from the rupture of a chain, the breaking of a ring, an irregular winding upon the "drum," a careless oversight of the engineer in managing his wonderful but delicate power—all these have been occurring weekly if not daily in the collieries of Belgium, France, and England, with the loss of, now a single miner, now a cage-load, until humanity was aroused and cried out loudly for an amendment. As long ago as 1845, it would seem that M. Machecourt had introduced a contrivance which he styled a "Parachute" into his mines at Decize, by which, though the rope broke, the cage was suspended in the pit, and its load, if it happened to consist of flesh and bones, instead of coal, saved from certain death.

Though M. Machecourt took out no patent for this invention, and gave, as it appears, liberal publicity to it, very little notice seems to have been taken of it, and England, at least, has been going on in the old way of economy and butchery, for ten years, without the invention being regarded or even perhaps known of.

The *principle* of this "Parachute," for which M. Machecourt has been rewarded with medals by the "French Institute," is as much like that of one form I have seen of the ordinary "steam-engine governor," as can be. Without going into a particular description, which would take up more space than I have to devote to the subject, if your readers, the next time they see an engine, will just look at the "steam governor," and will imagine the balls on the ends of the two arms to be replaced by iron claws that resemble forks; and the rod that runs up from the top, instead of being used to open and shut valves for the admission or exclusion of steam from the boiler to the piston, to be fastened to the *rope* used in raising and lowering loads in a pit; and the whole concern to be attached to the cage in which the complement of coal or colliers is being dragged, by the power of steam, to the surface; they will be prepared to comprehend fully the action of the "Parachute."

Extending from top to bottom of the pit, on each side, is a wooden guide, always used in pits of any depth, to prevent the cage from swaying to and fro in its ascent or descent. Up these the cage slides, as the piston rod of an engine would glide along *its* guides. Arrived at a certain point, a terrible number of yards to look down from the top to the bottom, suppose the *rope to break*—perhaps the wind has blown the winds off the drum at the top, and a sudden jerk has snapped asunder the frail threads; or a pulley wheel has given way, contrary to everybody's expectations, and to the proprietor's "deep regret;" or, to the endless surprise of the individual whose duty it is to look after it, and who never, under any consideration, neglects that duty, the iron ring which fastens the rope to the cage is suddenly ruptured; or, because it is more economical to use the old rope which has had the advantage of enjoying enough years of experience to grow rusty in the service, a month or two longer, rather than replace its threadbare fifty or a hundred or two

hundred fathoms, by a new one—the old veteran at the twelfth hour breaks down, to the everlasting wonderment of the pennywise proprietor, who has seen it work for six years without cutting up any such philanders; suppose any of these things to happen (and they are liable to happen at every colliery at any moment), what then? Under the old order of things, the contents, be they men or minerals, were dashed to fragments at the bottom of the pit—if minerals, it was an unlucky thing, but very fortunately there was nobody in it, which there might have been at the next draw; if men, a "crowner's inquest" sit upon their case, and come to the conclusion to agree to disagree upon whether the proprietor has used all ordinary precautions or whether he has not—"and there is no help for it."

But there *is* a help for it—and under the new order of things it is to be hoped no more of these accidents will, as it is certain no more *need*, occur. The "Parachute" invention does away altogether with the necessity of them. If the perpendicular rod of the "steam governor" above alluded to be forced down, the balls on the inclined elbows will fly out until they are nearly horizontal—so when the rod at the top of the safety cage *drops*, which it will do on being severed from the rope by a rupture and pulled down by its own weight and the weight of the elbow below, the arms of the Parachute, with the ready claws at their extremities, fly out just as the balls flew out—the claws grip the wooden guides on each side, the descent of the cage is arrested almost before it has begun, and the load of miners, instead of being dashed to instant destruction, have merely, suspended in mid air (if I may be allowed the expression), to bellow to the top to inform the "banksman" and his coadjutors of what is only an interesting predicament. All this is so simple that a child can comprehend it, and any mechanic in any country is competent to fill up the details. I have said there were three of these "life safes" exhibited by France. Besides M. Machecourt's, there are two others which are improvements—that is to say, in them either the action is more simple, or less material is consumed, or the *arrest* is rendered more certain and efficacious. They are all of them of the size of life, that is to say, are not models but actual constructions identical with those at present in use in French mines.

The first we shall notice is that of M. Fontaine, and called, after the inventor, the Parachute-Fontaine. This was tried for the first time in one of the extensive Anzin company's collieries in North France, in 1851. Since then a dozen have been introduced, and twenty-one lives saved from a certain death. A number of breakages have likewise taken place without workmen being in the cage, but always has it acted efficaciously The following will show you how these sort of inventions are encouraged in France. Extract from Report of French Institute, Academy of Sciences, 1854: "The Parachute-Fontaine has already prevented many accidents. It has saved the lives of sixteen workmen. It has been tried in the presence of Engineers of mines, in the Department of the North, and of Hainault, Belgium. It has always acted perfectly. The Institute of France award P. J. Fontaine a prize for this invention. Signed, Florens."

The Valenciennes society has also granted him a medal. But what are medals? The gratitude of twenty-one men saved from a fearful death, to the author of the invention without which their fate would have been soon determined, is more than medals. Since the opening of the Exhibition, the 7th of last July, ten more workmen have been saved, at the colliery of "Good Hope," Belgium, and two, the 30th of May, at Anzin, France. The action is very similar to that of M. Machecourt's, but there is less stuff and greater simplicity.

The other life-safe is that of M. Jacquet, of Arras. It is probably the most perfect one yet in existence. The clamp, instead of acting sideways against the guide posts, arresting descent by a push, which might cause the guides to sway or break, if perchance not supported by the wall, is caused to act crosswise so as to shut it between maws, as if a vice had it. The arrest is

also a clamp and not a claw—there are two on each side, at top and bottom of the cage.

The original idea of Jacquet was to have the top of the cage on a hinge, in the middle, and the ends of this cover (pulled down by springs in case of a rupture) to clamp the guides—but the other mode is an improvement.

Now for figures—for it must come to the "almighty dollar" at last, however much we may look to the benevolence of the thing in the beginning. Well, then, the prices asked by M. Jacquet, of Arras, are as follows: For patent right alone, £25; for safety apparatus complete, with patent right, £40; leaving £15 or $75 to represent the cost and profit upon the manufacture. What a trifling outlay for such an inestimable advantage! The saving of two or three cages (to say nothing of the men in them, or the time and trouble occupied in "juries," "inquests," and the abandonment of work by friends to attend funerals, &c., &c.) would alone repay the operator for the outlay. It may be interesting to you of the Schuylkill to learn that the wagons, hoisters, &c., exhibited by these French collieries are of iron, and that Monsieur Jacquet furnishes them at the rate of $10 a cwt.

But another European state, Belgium, exposes two different specimens of the identical Parachute, under the name of "arrests," which it may be well to allude to.

The first is the idea of one Pierre Dony, of Liege, and is called the "Arrest cuffat;" it operates very much like the first I described last week, and like it has the disadvantage of acting *sideways* against the guides in the pit. This is a disadvantage, because, should the guides be weak or unsupported by the earth behind at the point where the rope chances to break—so sudden and forcible a thrust as that made by the arms of the "Arrest" might cause them to give way, and the cage would, as under the old order of things, be precipitated to the bottom. But it is nevertheless a valuable invention, and in simplicity can hardly be surpassed.

By an article published in the "*Liege Journal*," 18th June, 1855, we see that it has already been tried.

"On the 18th instant, a cage containing a wagon of coal, total weight one and a half tons, had arrived in its ascent about thirty-five yards from the surface, when the ring which held the suspension cable broke, and the whole machine remained suspended in the pit. The teeth of the "Arrest cuffat" were found to have penetrated at least the one twenty-fifth part of an inch into the iron guides, which, below this point, had not the slightest trace of the instrument—proving the stoppage to have been instantaneous. Business was resumed at the end of half an hour." The entire weight of cage (which is two-storied) and "Parachute," in this machine, is 800 pounds.

Then, another Belgian sends a sample of a plan invented by him, which is in use at ten collieries of France; and, at the mines of Charleroy, last May, saved the lives of eight men, who were ascending, when something gave way—but the machine remained suspended, though a weight of nearly four tons, including many fathoms of the broken rope, had to be supported. Hitherto, it seems, the Government of Belgium has prohibited workmen from riding up and down in the cages, on account of the frequency of such accidents, constraining them to ascend and descend by the long-inclined ladders, than which, after a day's hard labor, nothing could be conceived more fatiguing or dispiriting. But, since the appearance of these Parachutes, the administrator of mines has recommended them to replace the ladders, and it is probable that they will do so, altogether, in the course of a very few months.

In this plan, the guides are narrow ladders, and the arrest catches on their rounds, being thereby suspended instead of by clamp or claw, as in the cases previously described. The author offers a bill of the different items of cost encountered in fitting up a pit for work by his form of cage, from which I am confirmed in the belief that the ladder plan is uselessly expensive. Single guides are as efficacious and one half cheaper.

This finishes all I have to say of the Parachute invention. It is to be hoped

that no coal operator on the Schuylkill or Lehigh, who wishes himself to be considered decently humane, will project a shaft without arranging to have the life safe included—or will defer introducing it into those pits he has already in operation.

It is often very difficult to get *horses* down mines—partly because, as when the pits are of the Staffordshire gauge, that animal has a natural disinclination to crouch up into less than his usual compass, to suit the dimensions of a black hole with which he is not at the best on any too good terms—and partly because of the difficulty of keeping him perfectly quiet and free from moving during the descent. Monsieur Faiche, a native of France, taking it into his head to remove these difficulties, shows to the world in the coal-mining department of the great Exhibition "an apparatus for lowering horses into mines," which he tells us has been in operation for some time at the collieries of Decize, and whose action he illustrates by an amusing portrait of one of the unfortunate beasts descending in it, to his dreary prison-work. It consists of four wide hemp bands, as high as a horse is long, and three lateral braces, which can be buckled up after the animal has been enclosed; thus, with his legs hugged up around his neck, and only his tail left sprawling, he descends, lengthwise, looking as funny and foolish, but nevertheless submissive, as can be imagined. Once down, and it is well known that "such attachments does he form," he seldom wishes to come up again.

This suggests a machine, or rather a *plan*, exposed under the flag of Belgium, though something similar has long been in operation in Cornwall, for raising and lowering miners in deep shafts. Instead of one cage being drawn by the winding of its rope round a drum at top from such great depth to the surface, advantage is taken of the locomobility of the human frame, to raise it, like so much weight of water pumped up by several lifts.

Just as in the case of a pump, an engine at the surface causes a long rod, the length of the pit, to rise and fall a certain distance, say nine feet, at every stroke. In the present case, there are two such rods rising and falling nine feet alternately. Attached to the rods, which are immense beams, double, at every length of stroke, that is at every nine feet, are railed-in platforms, large enough to hold from six to ten men. Fancy a half-dozen men to have stood themselves in the platform of No. 1 rod, at the bottom of a deep pit—in due time its turn comes to rise; up it goes by the power of steam nine feet; there it stops—its work is done—its whole mission is to go up that nine feet and then come down again—and so on, *ad infinitum*. But the men find a platform on the other rod, ready to receive them at this point, and without any ceremony step into it; up it goes, nine feet, but no further; its business is to drop again, but not the men with it; they step out into an upper platform, on the other rod, whose duty it now is to ascend—and so on until they reach the top. Whilst any particular platform of the two rods makes only its little excursion of eighteen feet, both ways, the men by taking advantage of this motion, being alternate, are stepping from one to the other, and thus gradually are raised to the surface.

In the 15 and 1800 feet shafts of Cornwall, many such machines are in use; the one at present referred to is a large model of that established in the coal mines of Mariemont, Belgium, by M. Warocque. The depth of this pit is 1620 feet; the number of panniers or platforms, 180; the double travel of the machine, 18 feet; the ordinary speed, 2½ feet per second; the time of stoppage at each pannier, 3 seconds; the time required for raising 160 workmen and for lowering simultaneously 160—one hour; and without danger this number could be tripled.

Thus it will be seen, that though for raising a single man 20 minutes is required, yet in three times 20 minutes at least 200 can be raised, and the same number lowered: which, for deep pits, working a great number of men, and especially for those employing two shifts, one going out at dusk and the other force entering to supply its place until morning, is a wonderful economy of time and power.

The very ingenious modification by which M. Warocque has applied this plan to the raising of wagons of coal as well as laborers, does not appear to have been as yet put in practical operation any where, though there would seem to be no reason why it should not be. The wagon loaded with coal is caught up by hooks on one rod at the bottom, raised its allotted distance and handed over to hooks on the other rod, and so on until it emerges at the top, whilst a new load has been caught up below, at every stroke of the machine.

LEHIGH COAL AND NAVIGATION CO.

The Board of Managers submit to the Stockholders the following Report:

In the spring of the year 1855, the Company's navigation having been, during the preceding winter, greatly improved and thoroughly repaired, was ready for business on the Lower Section by the middle of March, and on the Upper Section on the 25th of that month.

In consequence, however, of the protracted cold weather, and of the obstruction of some of the pools and levels with ice, the actual opening did not take place at Mauch Chunk before the 30th of March; and at White Haven, at the head of slack-water navigation, not until the 14th of the following month.

A partial beginning in the shipment of coal by the Company from Mauch Chunk was made on the 4th of April; but the business did not exhibit much animation until about the middle of the month.

With few and unimportant exceptions the navigation continued without interruption to the close of the season on the first day of December last.

For the year 1855, the shipments of coal from the region were 1,275,051 tons; showing an excess of about 25,000 tons over the estimate contained in the last annual Report, and an actual increase of 28,683 tons over the shipments for the year 1854.

The coal was from the following sources of supply:

	Tons.
From the Company's Summit Mines	312,354
" Room Run "	79,855
" East Lehigh "	35,190
Total from the Company's Mines	427,399
" Beaver Meadow Mines	88,588
" East Sugar Loaf "	51,451
" Spring Mountain "	179,220
" Colerain "	97,925
" Hazleton "	160,197
" Cranberry "	84,550
" Diamond "	88,454
" New York and Lehigh Mines	88,555
" German Pennsylvania "	4,195
" French American "	7,464
" Stafford "	10,309
" Council Ridge "	1,757
" Buck Mountain "	86,079
" Wilkesbarre Coal Co. "	47,762
" Wyoming "	2,446
" Beaver Meadow Pea Coal "	604
" A. Lathrop's "	2,845
Total shipments in 1855	1,275,051

In addition to the above, 22,413 tons were taken, during the year, from the Company's F. vein, leased to the Messrs. J. & R. Carter.

The Company's Tamaqua mines are not quite ready for business, the breaking machinery and fixtures being as yet unfinished.

The lessee, Mr. William Levan, is of opinion that his preparations will be completed in the course of a couple of months. The prospects are very encouraging for an abundant and increasing production of coal from this portion of the Company's property.

From the East Lehigh mines, Mr. Lentz, the lessee, calculates upon a large increase upon the production of last year. The coal is of excellent quality, and in great abundance.

The distribution of the coal from the region was as follows:—

	Tons.
Consumed on the line of the Lehigh Canal	229,056
Passed into the Morris Canal	290,730
Entered the Delaware Division	755,265

Of the last named quantity, 545,480 tons reached Bristol; 156,340 tons passed, by the outlet lock at Wells' Falls, into the navigable feeder of the Delaware and Raritan Canal; the remaining 85,445 tons were required for consumption on the line of the Delaware Canal.

The shipments of lumber for the year 1855 reached 54,587,567 feet, showing an increase of about four and a half millions over the shipments for the preceding year.

Freight of all kinds for the year amounted to:

Descending	1,445,499
Ascending	98,147
Total	1,543,646

being an increase over that for the year 1854 of 24,364 tons.

The freight list for 1855 is as follows:—

Freight transported on the Lehigh Canal in 1855.

	Descending.		Ascending.		Total.	
	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.
Anthracite coal	1,276,867	04			1,276,867	04
Bituminous coal			456	11	456	11
Charcoal			6	09	6	09
Grain	195	13	2,385	06	2,580	19
Flour	695		1,358	15	2,053	15
Salt	6	04	1.026		1,032	04
Salt fish, beef and pork	18	19	728	19	787	18
Other provisions	26	03	818	11	844	14
Beef, porter and cider	1	10	26	07	27	17
Whiskey	1,100		189	02	1,289	02
Hay and straw	40	10	250	12	291	02
Staves, hoop-poles, posts and rails	145	13	50	03	195	16
Lumber	65,965	19	3,281	17	69,247	16
Cordwood	1,369	05	40		1,409	05
Brick	109	05	1,788	03	1,897	08
Slate	4,879	14	378	15	5,258	09
Lime and limestone	19,476	03	8,145	06	27,621	09
Other stone and plaster	1,684	12	2,751	01	4,435	13
Iron	64,541	18	7,464	02	72,006	
Iron ore	7,249	01	63,488	15	70,737	16
Pitch, tar and rosin			94	02	94	02
Merchandise	1,631	02	4,023	18	5,655	
	1,445,498	15	98,147	14	1,543,646	09

Notwithstanding that the sales of coal from the Lehigh region were very sensibly interfered with by the exceedingly low rates at which Schuylkill coal, much of it of inferior quality, was forced upon the market, the business of the year was by no means of an unsatisfactory character, as will be made apparent by the following abstract from the more detailed statements herewith submitted.

The profits for the year 1855 were, from ground and water rents and from lots sold $31,224.71; from coal, $252,768.83; and from tolls, $735,278.09; making a total of $1,019,271.63.

The balance, at the close of the year, to the credit of profit and loss, after providing for State tax, interest, repairs, improvements and expenses, was $711,249.58; exhibiting an excess of $87,588.78 over the corresponding balance at the end of the year 1854.

The assets of the Company comprise at this date, April 30, the following items constituting the contingent fund, held in trust, and subject to the orders of the Board, viz.

Pennsylvania State Fives	$400,000 00
" Sixes	10,000 00
City Sixes	74,000 00
Pennsylvania Railroad, 2d Mortgage Bonds	200,000 00
Lehigh Valley Railroad, 1st Mortgage Bonds	16,000 00
Lehigh Coal and Navigation Company's Sixes	263,577 89
Amounting to	$963,677 89

During the year 1855, the capital stock was increased by $1,800; the funded debt was diminished by $495,400; the floating debt lessened by $56,655; and the general indebtedness of the Company reduced by $556,328.23.

On the first of January last the aggregate of the Company's liabilities, including capital stock, funded debt, and obligations of every kind, and including also their own loans held in trust, was $6,774,472.37.

Excluding the item last named, the amount was $6,485,594.98.

The accounts herewith submitted present a detailed exhibit of the financial condition of the Company, which can scarcely fail of being satisfactory to the Stockholders.

During the year the regular semi-annual dividends, of 3 per cent. each, were made upon the capital stock. A distribution of scrip, not entitled to dividend, was also made among the Stockholders to the amount, at par, of $494,650; and an equal amount of the six per cent. loans of the Company cancelled.

For the present season the production of coal from the Lehigh region will, as heretofore, depend upon the activity of the market, the extent of the demand, upon the boating force, and upon the trade being exempt from casualties and interruptions.

The supply of boats and boatmen is good; and, should the demand warrant it, the Company, as well as many of the other operators in the region, are in a position materially to increase their production. Thus far the aspect of the market, notwithstanding the introduction of some disturbing elements, is favorable; and there seems to be good reason to anticipate an active business with improving prices.

From the Company's Canal there will be some diversion, by the Lehigh Valley Railroad, of the trade from the second coal field; but it is not supposed that it will be to an extent greater than will be compensated by the increased shipments on to the canal from other quarters, and especially from the Wyoming Valley, by the way of the Company's Lehigh and Susquehanna Railroad and White Haven.

The indications are distinct and strongly significant of the approaching rapid development and growth of a large and valuable trade by this feeder to the Company's navigation. To accommodate this expected expansion in the business of the road, additions have been made to the rolling stock upon the line, and valuable improvements effected in the working of the planes; whilst further changes, intended to afford increased facilities to the trade, are projected.

From the accompanying Report of the Company's Engineer, it will be noticed that the important and very desirable improvements in augmenting the depth of water in the canal; in the rebuilding and enlarging of old locks and the construction of new ones; in the substitution of drop gates for swing gates; in raising and strengthening the canal banks; and in the construction on the berm bank of a second towing path, referred to in last year's Report as having been begun, have been zealously prosecuted during the past season and winter.

Lock No. 10, on the Upper Section, has been rebuilt of the full width of 22 feet. On the Lower Section several new locks, including an outlet lock into the pool of the Lehigh River at South Easton, have been begun, some of

them completed, and the remainder soon will be; the bridge over the pool of dam No. 8, intended for the accommodation of the boatmen and their teams, is about to be finished and brought into use; twenty-one miles of new towing path have been made; the deepening of the canal to not less than six feet water has, with the exception of a very few miles on the Upper Section, been accomplished; and a new weigh scale, of improved construction, of great sensitiveness and accuracy, and not liable to accident and injury from fire, has been put up.

These, with minor improvements, all of which are described in the Engineer's Report hereto appended, have necessarily involved a considerable expenditure; but, on the other hand, the capacity of the canal has been thereby greatly enlarged, and the transit of freight very much expedited.

The Managers are gratified at being able to report that an appropriation for the improvement of the Delaware Division has at last been made by the Legislature, which, however small in reference to the magnitude of the interests involved, will yet, if judiciously and economically applied, accomplish much towards securing the additional depth of water indispensable to a successful competition with rival avenues to market.

It is hoped, too, that this Act of the Legislature may be regarded as initial in its character, and as indicative of an intention to persevere in a policy thus happily begun until this most productive portion of the State works has been brought into a condition, in some adequate degree, commensurate with the wants of the trade and with the capacity of the canals, of which the Delaware Division forms the connecting link.

The Morris Canal, furnishing a very valuable outlet to the trade of the Lehigh, with a steadily growing business, and under an intelligent administration, is improving from year to year in its capacity and in the facilities offered to those who use this route to market.

About the first of April of the present year the repairs to the Company's Canal were completed, and the Lower Section ready for the admission of the water; and the Upper Section was ready very soon after. But, in consequence of the extreme severity of the past winter, the depth of the frost in the canal banks, and the prolonged obstructions from ice, the navigation did not actually open from Mauch Chunk before the 14th, and from White Haven not until the 18th of the same month.

Shipments of coal from the former place began on the 14th of April; but were again suspended for several days by a rise of water from frequent rains, and from the melting of the snow at that time still remaining in the mountains; subsequently they became more regular, and have since then been steadily on the increase.

Very nearly the whole of the probable production of coal from the Company's mines for the current season has been disposed of at prices which would seem to insure its being promptly and regularly called for; whilst the barrenness of the market, and the condition of trade and manufacturing industry generally, appear to warrant the expectation of a healthy and remunerating business for the year.

By Order of the Board of Managers.

JAMES COX, *President.*

COAL MEASURES AND AGGREGATES.

In statistics of coal, when the number of tons reaches millions, the mind receives no definite impression, or very slight; as is the case in speaking of planetary and siderial distances. A larger measure than the ton seems desirable, and an image of form which may be easily and definitely conceived. The receipts at Philadelphia by the Reading Railroad, for the year ending December 1st, are stated to be 2,205,281 tons, an advance of about 12 per cent. on the receipts of the preceding year. The common reader understands the latter circumstance,—the advance,—but of the former—the tons—he has

the idea only of a huge quantity, which might as well have been any larger number.

The average weight of a cubic foot of coal is exactly 96 lbs., and proximately in miners' language, 100; and a cubic yard, containing 27 cubic feet, weighs 2,240 to 2,715, mean 2,601 lbs.; but at the mines a yard is estimated at a ton of 2,240 lbs. These differences, though important in the city market, are not regarded at the mines when speaking of excavation, and they will not seriously affect our present purpose. Let, then, a cubic foot weigh 100 lbs. and a cubic yard a ton.

Now, a cube of coal measuring 10 linear yards, or 30 feet in diameter, will contain 1,000 cubic yards or tons of coal; and if we cut it into four prisms, and place them coincidently, one above another, we shall have a prism of 15 feet square by 120 high—a base as large as an ordinary sized room in a dwelling-house, and a height about that of the dome of the State House in Boston. Such a prism contains 1,000 tons of coal, and almost any one can form a clear conception of its magnitude.

Again, a square acre contains 160 square rods, and one side measures 12 2-3 linear rods. If within this area we erect 100 of our prisms with spaces of six feet between them on each side, as we may, we shall have on one acre 100,000 tons of coal. On ten acres we might erect 1,000 prisms—1,000,000 tons of coal; and this cohort of black towers may be as easily conceived as the company of 100 prisms on the one acre, or the unit prism with which we started.

1 cubic foot of coal	100 lbs.
1 " yard "	1 ton.
1 " prism "	1,000 tons.
1 acre contains 100 prisms	100,000 tons.
10 " " 1,000 "	1,000,000 tons.

We may now proceed more intelligibly in speaking of aggregates. The consumption of Boston, or rather the receipts at Boston for the year 1853, were 426,998 tons; for 1855 probably 500,000 tons. This would require for its 500 prisms, placed as above, 5 acres—1-15 part of Boston Common. The receipts at Philadelphia by the Reading R.R. for the past year, 2,205,281 tons, would require for its 2,205 prisms, 22 acres—nearly one third the common. The anthracite beds of Pennsylvania, and they are the only beds of that specie in the United States, all lie east of the Susquehanna. The production of these mines for 1854 was 7,278,750 tons, which would require 72 3-4 acres for its prisms—a space as large as the whole common. Moreover, the total production of these mines since the first shipment in 1820 of 365 tons, is 57,228,689 tons, which would cover a space eight times as large as Boston Common.

Once more, these anthracite beds cover an area of 437 square miles (see "Statistics of Coal," by R. C. Taylor) of *workable* coal—meaning by *workable*, veins not less than three or four feet in thickness. Taylor estimates the thickness of vein for the whole coal field of Pennsylvania, both anthracite and bituminous, at from 10 to 15 feet. But as the anthracite much exceeds in thickness the bituminous, it is probable the average of the anthracite is at least 15 feet—many being 40, and some 50 and even 60 feet thick. Now, an acre of coal with a vein one-foot thick, is found to yield 1,000 tons—one of our prisms. Hence, a vein of 15 feet will give 15,000 tons to the acre. But 437 square miles equals 279,680 acres, which, multiplied by 15,000, gives the incomprehensible number of 4,247,700,000 tons. But apply the prismatic unit, and reduce the tons to cohorts of black towers, one hundred to the acre as before, and we shall get them upon an area of 66 square miles—a township of a little more than eight miles square.

Or to take a larger unit. If we consolidate a thousand of our prisms—1,000,000 tons, into a cube, that cube will be 300 feet high; and there will be 4,247 such cubes, each occupying an area of two acres: and the whole, an area of 13.7 square miles with no spaces between. With them a wall might have been built around ancient Nineveh, whose circumference was 60 miles, 600 feet high and 600 thick. Placed contiguously in a straight line they would extend 960 miles.

Will those anthracite beds ever be exhausted? If the estimate is fair—437 square miles with an average thickness of 15 feet—they cannot last always. The past year has abstracted six of our great cubes. At that rate 700 years would scoop the beds about clean. But the consumption will very soon be doubled. For the next one hundred years, it is not extravagant to set the annual consumption at twenty of our cubes (20,000,000 tons) which would exhaust the mines in a little more than two hundred years.

CANNEL COAL AND ITS PRODUCTS—IMPROVEMENT OF COAL RIVER.

A proposition is now before the Legislature for an increase of the capital stock of the "Coal River Navigation Company," in the additional sum of $100,000. One hundred and twenty-two thousand dollars have already been expended by the Company in the improvement of the river; and it is now asserted, after the most careful estimates, that by a further expenditure of one hundred thousand dollars, the entire work can be completed. The "Western Mining and Manufacturing Company" own immense, and we might say, practically, exhaustless fields of cannel coal bordering this stream, at a distance of thirty-six miles from its mouth, and, as a matter of course, are deeply interested in the progress of this improvement. To facilitate the completion of it, they now propose to purchase of the State her bonds to the amount of sixty thousand dollars (three fifths of the increase asked for by the Navigation Company), thereby investing the State with the funds necessary to pay her proportion. They further propose to subscribe the remaining forty thousand dollars at once, so there may be no delay in the prosecution of this great work.

It is estimated that 5,000,000 bushels of coal will be shipped annually over this improvement to the Big Kanawha, thence to the Ohio River. The tolls accruing to the company will be about one cent per bushel, which would be $50,000 on the aggregate amount. The tolls on shipments of coopers' stuff, sawed lumber, &c., &c., and upon return trips, will not fall short of $15,000. If these estimates are verified—and from the data before us we doubt not they will be fully—the work will be a profitable one to the stockholders, while, at the same time, it will develop the rich mineral treasures of the section of country it traverses. The coal fields of Pennsylvania are taxed in some instances as high as four hundred dollars per acre, pouring anuually into the treasury of the State immense sums of revenue. It is but fair to infer that, with equal facilities of transportation, this commonwealth would find in the coal fields of Kanawha and Boone Counties equally as prolific sources of wealth. The Covington and Ohio Railroad, which is but a continuation of the great Central route, crosses Coal River near its confluence with the Kanawha. At an early day after the completion of these improvements, it is not unreasonable to assume that the great superiority of the cannel coal over all other, as an article of fuel and a producer of light and heat, will bring it into general use in the eastern cities. Three fourths of the cannel coal yet discovered in the United States lie in Western Virginia, constituting one of the richest mines of wealth that has ever been developed in any country, not excepting the auriferous streams and hills of California.

From this coal is extracted, at a cost not exceeding 16 cents per gallon, a valuable lubricating and burning oil. Probably some of our readers may have noticed, a few evenings since, upon the clerk's table of the House of Delegates, a lamp containing this oil. The clear, bright flame emitted actually made the candles around it look dull and dim. It burns free from all offensive odor and smoke, and this fact, in connection with its cheapness, must insure for it an extensive and general use. The yield is forty gallons per ton. It also yields thirty gallons of benzole per ton, which is easily convertible into gas, and must eventually supersede the gas at present in use in our cities. From twenty to twenty-five pounds of clean, white wax are also produced from a ton of cannel coal, which are made into candles of adamantine firmness.

Some fine specimens of this coal, from the mines of the "Western Mining and Manufacturing Company," have been exhibited here during the session, by J. E. Peyton, Esq. A lump has been upon the clerk's table, in the Hall of Delegates, for the past week or two. It has been very justly admired for its firm and beautiful texture, and its freedom from dirt.

We hope it will be the pleasure of the present Legislature to extend its aid to the Coal River Company, and place them in a condition to develop the treasures of our State. The operations of the mining companies interested in the improvement of Coal River will be greatly retarded if something is not done before the adjournment.—*Richmond Dispatch.*

CALLAWAY MINING COMPANY.

Extract from a letter dated St. Louis, August 5.

"Within a couple of weeks past, the coal cars of the Callaway Mining Company have been actively engaged in transporting the products of their valuable mines to the company's landing on the Missouri River.

"These mines are reached by a railroad 6 3-4 miles in length, just completed, and well equipped, with all the necessary rolling stock, and an additional first-class locomotive, manufactured expressly for the company by Messrs. Norris & Sons, of your city.

"This coal is said to be of a superior quality—not much unlike the celebrated Boghead Cannel of Scotland; it extends over the greater part of the company's property, in veins of *over twenty-five feet in thickness.* The miners quarry it out (so to speak) in blocks of immense size, and the quantity presented full to view, in the bluff they are now working, would seem to prove the supply positively inexhaustible.

"The demand at the landing for the Callaway coal must become very great, both up and down the river, supplying it from St. Louis to New Orleans, since for gas, steam purposes, or household use, it has no rival, apart from the recently discovered oleaginous properties it possesses, which give it an increased value."

We are glad to learn these facts, for it must be confessed that the operations and prospects of the company have for a long time been seemingly struggling under a cloud, while the company have been quietly building their road and bending every energy for the promotion of its best interests for ultimate success and profit.—*Evening Journal.*

COAL LOCOMOTIVES IN THE WEST.

A report has been presented by James C. Clark, Division Superintendent on the Illinois Central Railroad, describing the economic results of using coal in locomotives in comparison with wood as fuel. He fitted up a wood-burning locomotive for burning coal, and he made twenty-one trips with it, running 2810 miles. The expense for converting the engine into a coal-burner was only $275, and the results have been gratifying. A wood-burning engine, running with it on alternate days, consumed 89¼ cords of wood in running 2810 miles, the cost of which was $289.32; the fuel for the coal burner amounted to only 38½ tons, and cost $115.50—less than one third that of wood. The cost of wood for all the other engines used on the railroad was in the same proportion.

The fire-box of the coal-burner did not appear to be the least injured by the twenty-one trips, and the grates were not warped in the least. The fuel was bituminous coal—that belonging to the Illinois coal fields. All of our railroads will yet be driven to the use of coal for fuel; it is the cheapest they can use now, and the sooner they institute measures for its universal adoption so much the better for themselves.

THE AUBURN AND ALLENTOWN RAILROAD—THE NEW JERSEY CENTRAL, &C.

As every thing which refers to the proposed Auburn and Allentown Railroad is, at this juncture, interesting, we ask attention to the annexed notices of this important line, contained in the last Report of the Central Railroad of New Jersey. In the Report, which is dated June 1st, 1856, but which has just been published in New York, the paragraph we extract is found under the head of "connecting lines"—in which category, we might remark, the Reading and Lehigh Road is not referred to. The Auburn Road is thus noticed:

"The link of road from Allentown westward, to connect with the Pennsylvania Central Railroad, and thus form an air line of unbroken gauge from New York to Pittsburg, still remains to be supplied. Important as this enterprise is to the country through which it will pass, a country rich in soil, in cultivation, in minerals, in every thing but avenues to a market; to the city of New York and the Western States, brought by this channel into more intimate connection; and to the Central Railroad of New Jersey, which it will supply with an entire new source of traffic; it cannot be much longer delayed. Little as the public are disposed to embark in new railroad enterprises till the results of previous investments are more certainly ascertained, the advantages of these links are so obvious to all concerned, and especially to the business classes of New York, that there can be but little hesitation in furnishing the comparatively small amount required for its construction."

The importance of the Auburn and Allentown Railroad to the trade of this section of Pennsylvania is not questioned. It is a fact readily admitted. The most interesting query has been, how are the grades of the Central Jersey Railroad, a road which forms so important a portion *of our preferred coal route to the harbor of New York?* The Report from which the above extract is made, relieves all doubts on that score. For the gratification of this community, which is warmly interested in this route, we make the following extract, which proves that on the score of grades, not to mention distances, this proposed continuous coal route to a favorable shipping point is the best to which the attention of the people of this region has yet been directed. The extract in regard to grades, &c., of the Central Jersey Railroad is as follows:

"Many small variations in the grades of the older part of road below Somerville have been corrected, and the reduction of the heavy grade at Scotch Plains, from 45 to 21 feet per mile, has been finally effected. It is a matter of some credit to our efficient superintendent and engineer that this reduction, involving, as it did, the entire reconstruction of three miles of road, raising or lowering the track in some as much as 16 feet, and extending over a period of two years, has been completed without accident to trains or interruption to the business of the road; the regular passenger and freight trains having been run over it during the whole time. *There is now no grade on the road over 21 feet to the mile against the trade.*"

In the Report we also find the following relative to the coal port at Elizabethport, N. J. It is interesting, affording as it does an idea of the improvements which have recently been made at that important shipping point:

"At Elizabethport the construction of track, wharves, and buildings has been continued, and a large amount of grading and filling at moderate cost. An additional and very valuable tract of land, including the water-front, and lying east of the company's land, has been secured; and immediately contiguous to this, the Delaware, Lackawanna, and Western Railroad Company have purchased a large tract, and established there their coal depot. All coal, lumber, &c., from the Lackawanna region are brought to Hampton in their cars, hauled over our road by our engines, and delivered on their grounds. All wharves, tracks, &c., required, are furnished by them. These arrangements, by relieving this company from a large outlay for cars and a terminus, enable us to do a very large business from the Lackawanna region, with a trifling

additional investment after the second track and the third rail on the two tracks are provided.

"It also facilitates very much the necessary separation of the broad gauge business from that of the Central road and the Lehigh Valley railroad and its connections, which is done on the narrow gauge."

Before closing our notice of the Report of the Central Jersey Railway, we feel compelled to make another extract in reference to the two New York coal lines lately opened from other regions. That they have seriously injured our coal trade this year, cannot be denied. That it will yet be more seriously damaged in the future, if we pause in the construction of the Auburn and Allentown road, is equally evident. We are now placed in a position which demands prompt action, for the building of that road is likely to be the only salvation for the business of Schuylkill County. The Report speaks of the Lehigh Valley Railroad and Delaware, Lackawanna, and Western Railroad as follows:

"The Lehigh Valley Railroad was opened through from Easton to Mauch Chunk, 46 miles, in September last, thus giving a continuous line from the Lehigh coal fields to Elizabethport, 109 miles; to New York, 121 miles. The mines are about 17 miles above Mauch Chunk. As yet this road has done little business, having a very insufficient equipment, and laboring under some other disadvantages; but when these difficulties are removed it cannot avoid doing a large and profitable business, as it has all the advantages derived by the Reading road from a level or decending grade throughout its entire length; is likely to be without a rival in its location, and will have the benefit of many outlets for its coal and many feeders for its business. When its main line is extended from Perryville, 6 miles below Mauch Chunk, to Tamaqua, where it intersects the Catawissa road, a distance of 16 miles only, a large through business from the Sunbury and Erie road will be brought over to the Central railroad of New Jersey. This work is entirely within the ability of the Company to complete, as soon as their business is developed.

* * * * * * *

"The Delaware, Lackawanna, and Western Railroad and the Warren Railroad, together forming the line from Hampton Summit to Scranton, in the Lackawanna coal basin, the youngest in charter and latest in commencement among the coal roads, was opened throughout its entire length on the 27th May just passed, and is now in successful operation. Already the passenger, freight, and coal business of this road begin to develop, and it is believed by its friends that its success will be immediate. Every effort has been made and is making, by the Central, to give them every facility consistent with proper economy, and it is hoped that the relations of the companies will be as friendly as their business connections will be intimate. This is the more likely, as the large stockholders in each are generally interested in the other also. If one-fourth of the anticipations of managers of this company are fulfilled, the addition of this business alone to that of the Central New Jersey road cannot fail to make it highly remunerative. This Report has been delayed beyond the regular time to announce this opening."—*Pottsville Jour.*

IRON AND ZINC.

IRON SEAMS OF MONTOUR RIDGE, PENN.

A correspondent who has recently visited Montour County, Pennsylvania, sends us the following interesting particulars of that valuable iron region:—

The veins of iron ore in Montour Ridge are uniform in their strike and dip, but throughout the region, though the formations are regular, they undulate in the same manner as the coal veins of Shamokin, or Schuylkill County, and may be easily traced by the form of the hills in which they are found. Rolls or contortions are occasionally found, and as in the mines of Tamaqua and many other places often when least expected; but though the miner is sometimes at a loss to find his clue, or when found, to discover the best means of following it, the quantity or quality of the ore is not materially affected. As a general rule, the quantity of ore will not be increased or decreased on an average, by an inconsistency in the veins which may be at variance with their general size in any certain locality. (The same may be said of the veins of coal, though we are aware that the fact will not be generally admitted.) Up to the present time three veins have been discovered and worked in the Ridge near Danville, the upper one being, what is generally known as fossiliferous, the outcrops of which are soft and easily mined, whilst the lower portions, or that which is found deep beneath the surface, is imbedded in limestone, in which the impressions of fossil remains are plainly discernible. This is very hard, and not so easily mined. The upper vein will average about from eighteen to twenty inches in thickness, and is supposed to be the same vein as that which is worked at Bloomsburg. In fact I should say there can be but little doubt on that subject, since the stratification in which the vein is found is the same, and its nature and the appearance of the ore are synonymous, therefore it would be consistent to argue that the same quantity of ore exists at Bloomsburg as there does at Danville, for there can be no reason that I am acquainted with, to doubt the existence of the underlying veins there more than here. Yet I would like to hear what those who are more acquainted with the formation, may know of the matter, before I should be willing to state positively my opinions. Geologists are often mistaken in their theories, which are so boldly given as facts, of what the mysterious chambers of the earth may contain.

Mr. Roberts made a report of the Irondale Company of Bloomsburg, which I have not seen, neither have I any thing on the subject on hand. Yet I can state that one of our most eminent geologists (not Roberts) made some strange blunders in his examinations near Bloomsburg, which resulted in material loss to some, whilst it has been, or may be the means of enriching others.

The second or middle vein, which is worked in the Montour Ridge, is known as the "*black ore.*" This vein is situated about one hundred yards across the measures, or strata, below the upper or fossiliferous ore, and is on an average about twenty-four inches in thickness. This ore is very rich, and breaks in square fractures, and is the most productive and reliable vein in the region. On this vein, if I am not mistaken, the Montour Iron Company have sunk a shaft to some depth, and a slope—the latter, however, is not yet in order for operation. These works are rather extensive, and as systematical in their construction as our most improved collieries in the coal region.

The lower, or third vein of ore, which was discovered by the Messrs. Groves in 1854, is generally known as the bottom bed, but there are indications of other veins existing still below it. This vein is very hard and peculiar in its appearance, the ore being highly carbonized. It is not as thick as either of the overlying ones, but perhaps equally as rich if not more so. It ranges from ten to twelve inches in thickness. The three veins will average

about four feet of ore or over. The strata bearing these three veins is about two hundred yards in thickness—that is from the upper to the lower vein; the middle one being about equidistant from each. Their dip here, as at Bloomsburg, is north and south, from the saddle; no basin having as yet been discovered, though it has been asserted that the north dip of the south basin has been discovered on the south side of the Susquehanna at Danville, and specimens of rich magnetic ore shown as samples—one of which I have; but the more experienced are inclined to doubt it, and geologists flatly contradict it, because if it does exist, in the magnetic state, it would puzzle them to reconcile it to their theories. With much truth and some philosophy, the school-boy cries, "What goes up must come down." But with coal and iron veins the case is reversed, for when they go *down* they are *sure* to *come up*. With such a theory, which is more of a fact than a theory—the iron seams of this region would present two distinct basins; one to the south, and the other to the north of Montour Ridge. The distance from crop to crop of the basins must be from one to two miles, and on the saddles, though the upper vein crops out, and in some places the south and the north crop of it is from a half to a mile distant, the underlying veins do not appear to daylight, but overlap the saddle and continue the course without coming to daylight, except in the ravine or gorges of the mountain, where they are plainly discernible.

The strike of the veins are nearly uniform here with that of the coal seams to the south, and the same as that of the same veins in Columbia County, which is within a few points of east and west, extending from Briar Creek, above Bloomsburg on the east, to Hollidaysburg on the west, as it is supposed. A vast field of ore is here presented, equal in proportion to the anthracite coal-fields of the State, and admirably situated in regard to the facilities for mining—with every convenience in prospect, for obtaining the requisite material for manufacturing, and for transportation to ever ready markets.

Limestone of the purest quality is found as close to the furnaces as it could be desired, and in quantities commensurate with the vast amount of ore to which it is so important an auxiliary, and which lies so conveniently near.

The quantity of coal now made use of in the manufacturing of iron in this region, cannot be much less than 200,000 tons yearly, besides the large amount which is used for other purposes, and it would be no groundless assertion to state that 1860 would demand 1,000,000 tons of coal from the Shamokin and Wyoming regions, to be delivered on the river from Shickshinny to Sunbury, on the North Branch, and from Sunbury to Williamsport on the West Branch.

Danville, 1856. S. H. D.

In addition to the preceding, we append the following analyses of the ores of the same county:—

The anthracite furnaces of Columbia, Montour, Northumberland and Union Counties, use the fossil ore of Montour Ridge, and obtain their coal from the Wilkesbarre region. The ore of Montour Ridge presents several interesting characters, and produces several grades of cold short iron. The suface ore, and from those strata which have been affected by the percolation of water, are porous, work more easily in the furnace than the compact varieties, and afford an iron with less silica. The compact silicious and calcareous varieties are comparatively refractory, and when used alone, generally produce a silicious cold short iron. This is particularly the case with furnaces having low stacks, and that drive a too heavy blast. In general, the anthracite iron of this region is particularly adapted to neutralize the peculiar and most general properties of other anthracite pig, red shortness which is imparted by sulphur, where the presence of phosphorus does not counteract its influence.

The following are analyses of the fossil ores of Montour Co., Pa., as given by Mr. Boye, for Prof. Henry D. Rogers' Geological Report, 1841:—

	COMPACT ORE. DANVILLE. *Calcareous.*	ORE. DANVILLE. *Silicious.*	ORE. TURTLE CREEK. *Union Company.*
Peroxide of iron, ...	30.34	70.63	37.64
Oxide manganese, ...	a trace.	not given.	not given.
Carbonate lime, ...	62.43	2.46	do.
" magnesia, . . .	2.79	not given.	do.
Silica and insoluble matter, . .	2.64	23.77	59.00
Alumina, ...	not given.	.57	a trace.
Water, ...	1.80	2.57	3.20
Loss, ...			.16
In parts, . . .	100.00	100.00	100.00
Per cent. of iron, . .	21.08	48.97	26.32

By the above we may see that no mention is made of the important and generally present elements—phosphorus and sulphur. As the analyses of single specimens can rarely give an adequate knowledge of the composition of the bulk of the ore, it is prudent to examine those constituents, the presence of which is obvious from other considerations. Fossil remains of shells or other bony structures, we can safely presume to contain phosphate of lime; and crystals of pyrites afford indubitable evidence of the presence of sulphur. The qualities of the iron produced also, afford, to a great extent, evidences of the presence of certain elements, either in the ore, flux, or fuel; and without much trouble, as a general fact, the material containing the elements may be designated. This subject opens too wide a field of remarks for a full examination in this connection. To show more clearly what we consider as a proper statement of the composition of the ores of Montour Ridge, we give the following table, estimated from the analyses of Mr. Boye, and from the well-known composition of minerals disseminated through the ores, and from the properties of the iron and the comparative yield in smelting:—

	Hard Ore proportions varying from	Average Comp. in 100 parts.	Soft Ore proportions varying from	Average Comp. in 100 parts.
Peroxide of iron, ...	20 to 80 per ct.	50	40 to 80 per ct.	65
Peroxide of manganese, . . .	0 to 1 "	trace	0 to 1 "	trace
Carbonate of lime, ...	2 to 62 "	20	0 to 10 "	5
" of magnesia, . . .	5 to 8 "	1	0 to 1 "	trace
Silica, ...	1 to 30 "	24	1 to 30 "	20
Alumina, ...	5 to 8 "	2	trace to 5 "	2
Phosphoric acid, ...	trace to 2 "	1	trace to 1 "	1
Sulphur, ...	0 to 3 "	trace	0 to —? "	trace ?
Water, ...	1 to 3 "	2	1 to 10 "	7
		100		100

Average proportions of iron 35 per cent. in hard, and 44 per cent. in soft.

EXPERIMENTS WITH CAST METALS.

A work has recently appeared under the authority of the Secretary of War, which contains some valuable reports of officers belonging to the U. S. Ordnance Department, in relation to experiments made with cast metals:

The experiments were extended over a series of years, and were made to test the strength and other properties of metals employed in the manufacture of cannon. The work is a scientific one of great value, especially the information it contains relating to the nature and treatment of cast-iron, a material of deep interest to so many millions of people in our own and other countries. The experiments were mostly conducted under the charge of Major W.

Wade, who details them in an exceedingly clear and interesting manner. One new fact developed by them is, that iron fused a number of times up to a certain point, is thereby greatly improved in strength. In trials with some iron it was found that its transverse strength was nearly doubled by being melted and cast four times. This is a discovery of great importance to all engineers and cast-iron founders. At the South Boston foundry, experiments were made to test the strength of cast-iron which had been submitted to fusion during different periods of time. Eleven thousand pounds of iron were cast into four six-pounder guns: one after the metal had been under fusion or melted half an hour; the second, under fusion an hour and a half; the third, under fusion three hours; and the fourth, under fusion three hours and three quarters. The gun first cast burst at the thirty-first fire; the second, at the thirty-fourth; the third was fired thirty-eight times, and remained unbroken. Thus the strength of the metal seemed to increase in a ratio corresponding to the period of fusion, or under which it was kept in a highly molten state, and it might have been inferred from this that the fourth gun would have been the strongest of all. Instead of this being so, however, it proved to be the weakest, for it burst at the twenty-fifth discharge. In view of these experiments, Major Wade, in this report, says: "these results appear to establish satisfactorily the fact, that a prolonged exposure of liquid iron to an intense heat, does augment its cohesive power, and this power increases as the time of the exposure up to some (not well ascertained) limit, beyond which the strength of the iron is diminished." This is a new developed fact in relation to cast-iron, subject to concussions, of deep import to all engineers. Experiments were also made to test the transverse strength of cast iron bars, two inches square and twenty-four inches long, the metal of which was kept under fusion during different periods of time. These bars were set on supports twenty inches apart, and the breaking force was applied at the middle. The results obtained from four castings were in favor of that which was kept fused longest —three hours. On this head the report says, "from this it appears that the cohesive power of the iron, so far as it can be shown by its capacity to resist transverse strains, is increased 60 per cent. by its continued exposure in fusion." This is also a fact of importance to engineers and architects, regarding girders and beams, subject to a crushing force.

In most of the books which treat of the strength of cast-iron, the resistance which it opposes to certain strains is given; but little useful information can be obtained in them regarding the very great difference of strength in different kinds of cast iron. But as the density between the lower and higher grades of this metal differs as 6.9 to 7.4—a difference of 31 pounds per cubic foot, and as the tenacity of the metal has a relationship to its density, it was found by these experiments that cast iron, having a density of 6,900, had only a tenacity of 9,000; while that having a density of 7,400, had a tenacity of 45,970.

Castings of the greatest weight, according to their size, are by far the strongest, and weighing them is a ready means of judging comparatively of their strength.

Some important facts were also developed in relation to the cooling of heavy castings. At the Fort Pitt Iron Works, two eight-inch and two ten-inch guns were cast, one of each in the common way, solid, and one of each with a core on a tube of iron, through which water was made to circulate after casting, to cool it from the interior, according to an invention of Lieut. Rodman. The solid eight-inch gun burst at the seventy-third discharge; the hollow cast one stood 1,500 discharges, and did not burst; the solid ten-inch cast gun stood only twenty fires, while the hollow ten-inch gun stood 249. These guns were cast of the same material and at the same time, the difference in favor of the hollow cast guns is astonishing. This is attributed to the method of cooling, it being supposed that in cooling, the solid guns contract entirely from the outside, and that a strain is exerted upon the arrangement of the particles of the metal, in the same direction as the strain of the discharges.

Lieut. Rodman goes into a very subtle mathematical demonstration to show that this is the case, and that his method of cooling the casting obviates this unequal strain. But on the back of this, Major Wade presents a new fact in relation to the effect of time after the castings are made, and before they are used, which is also of vast importance to engineers. Eight-inch guns proved thirty days after being cast solid, stood but 72 charges; a gun of the same bore, proved thirty-four days after being cast, stood 84 charges, while one which was proved one hundred days after being cast, stood 731 charges, and another, proved after being cast six years, stood 2,582 charges. What in important fact is thus newly developed, showing us that solid cast iron should not be actively used until they have been kept for some years. Major Wade accounts for this phenomenon in cast-iron, by supposing that the particles strained in the cooling re-adjust themselves in the course of time to their new position, and become free or nearly so, and he presents some good arguments in favor of this theory.

The lesson to be derived from this by our engineers is, that heavy castings of iron for beams and machinery, subject to strains, are less capable of resisting them immediately after being cast; in other words, old castings are much stronger than new iron castings.

THE MANUFACTURE OF STEEL.

The method by which steel is manufactured is in its leading principle generally known. The interest in this pursuit must greatly increase in this country, and a statement somewhat in detail of the process of its manufacture may be instructive to many of our readers. Preparations are making to use the Lake Superior iron extensively for this purpose.

It has been clearly demonstrated that the Lake Superior iron can be converted into steel of the finest and best quality; and the Sharon Iron Co. of Pennsylvania, which owns the Sharon Iron Mountain of Lake Superior, is making preparations for entering extensively into its manufacture, intending to convert all their iron from Lake Superior into steel. The success of this enterprise (and there is no reason to doubt it) will form a new era in American manufactures, and give increased value and importance to Lake Superior iron, as no other kind in this country has been found capable of making steel that would at all compare with Swedes, English, Russia and Madras. Indeed, in Great Britain there is only one kind of iron, the Wolverstone charcoal, that can be converted into good steel; and with that exception, nearly all steel manufactured in England is made from Madras, Swedes and Russia iron.

Steel is iron passed through a process called cementation, the object of which is to impregnate it with carbon. Carbon exists more abundantly in charcoal than in any other fusible substance, and the smoke that goes up from a charcoal forge is carbon in a fluid state. Now, if you can manage to confine that smoke, and put a piece of iron into it for several days, and heat the iron at the same time, it will become steel. Heating the iron opens its pores, so that the smoke or carbon, enters into it.

The furnace for this purpose is a conical building of brick, in the middle of which are two troughs of brick or stone, which hold about four tons of bar iron. At the bottom is a large grate for the fire. A layer of charcoal dust is put upon the bottom of the troughs, then a layer of bar iron, and so on alternately, until the troughs are full. They are then covered over with clay to keep out the air, which, if admitted, would prevent the cementation. Fire is then communicated to the wood and coal with which the furnace is filled, and continued until the conversion of the iron into steel is completed, which generally happens in about eight or ten days. This is known by the blisters on the bars, which the workmen occasionally draw out, in order to determine when the conversion is completed. The fire is then left to go out, and the

bars remain in the furnace about eight days to cool. This is called "blistered steel." German steel is made of this blistered steel, by breaking the bars into short pieces, and welding them together, drawing them down to a proper size for use.

Blistered steel when reduced into smaller bars, and beaten under heavy hammers, forms what is termed "tilted steel." The building in which the operation is performed is called "a tilt" on account of the workman, when holding a bar of steel sitting in a kind of cradle suspended from the roof, and swinging to and fro as he thrusts or "tilts" the bar under the hammer. The word "tilt," as applied to this action, and to the rise and fall of the hammer, is of Saxon origin—implying to thrust at, and also to vacillate, or to move up and down.

Tilted steel, when broken, heated, welded, and again forged into bars, is known as "shear steel," from the circumstance of its universal employment in the manufacture of the best shears for sheep-shearing.

English cast steel is another variety of this protean compound of iron and carbon, and is obtained by melting steel with vitrifiable matter and charcoal, then casting it into the form of ingots, which are subsequently gently heated, and carefully hammered or rolled into the form of smaller bars.

Blistered steel and cast steel contains 98 to 99 per cent. of iron; the remaining portion consists of carbon.

Tempering Steel.—Steel which has been rendered excessively hard and brittle by heating to redness and suddenly quenching in water, admits of having its hardness reduced, and of acquiring elasticity by a process called "tempering." This admits of the following illustrations:

Let three strips of elastic steel, of equal length and breadth, and thickness, be placed on a clear glowing fire; when they become equally red-hot, remove two of them with a pair of tongs, and drop them into cold water; then remove the third and place it upon the hearth to cool.

Take one of the suddenly quenched strips and attempt to bend it by the strength of the hands; it will not bend but break short, and will scratch glass; so that the steel by this treatment becomes exceedingly brittle and hard.

Take the strip that has slowly cooled down upon the hearth; it will bend with the same facility as a similar sized strip of copper would bend; and, like it, will keep the form into which it is bent, and will not scratch glass, so that the steel by this treatment has become extremely flexible and soft.

Lastly, take the remaining strip of suddenly quenched steel, polish one of its surfaces with emery paper, then let the end of a large iron poker be heated bright red-hot, and afterwards be supported horizontally upon a brick or tile, placed on a table near the light; lay the strip of steel, with its polished surface uppermost, on the red-hot poker in the direction of its length; in the course of a few seconds the steel will present a curious display of colors, commencing with a straw tint, which gradually deepens to a brown, next to red, with streaks of purple, and ultimately to fine blue; let it be removed and allowed to cool. When cold it will be found to bend with readiness, and to fly back to its original straight form when the bending force is removed. It admits of being scratched with a piece of the brittle, hard strip; so that by this treatment the steel has become less hard than it was, and also regains its elasticity, or technically, it has acquired "spring temper."

The colors that appear upon steel, during the process of tempering, depend upon its iron sustaining slight oxidation, and is therefore rendered capable of decomposing light and of reflecting some of its chronic rays, or their mixtures; for when polished steel is heated out of the contact of the air, it retains its peculiar lustre and only reflects white light, yet it becomes perfectly tempered to any required extent.

The chemist has accurately determined the degree of heat by which steel may be suitably tempered for various implements, and has communicated another important fact to the artisan, that mercury may be heated to any degree short of its boiling point, so that a thermometer introduced into it will denote

the temperature at which any given temper will be acquired. The best temper for penknives is attained at the straw color. This appears at 450 degrees; accordingly, the mercury is heated to such temperature, and introducing two or three hundred hard steel blades, they will be effectually and simultaneously tempered without involving the tedious necessity of watching the appearance of the straw color upon each individual blade, as must be done if they were placed on heated iron.

The tempering of steel, therefore, consists in reducing its excessive hardness to a moderate degree, by gentle heating, which also restores its toughness and elasticity.

The various colors that announce its fitness for cutting instruments, and the temperature at which they appear, if it be heated in air, or at which temper is conferred, if it be heated under mercury, are hereby subjoined;

At 430 degs., very faint yellow, for lancets.

At 45o degs., pale straw, for razors and scalpels.

At 47o degs., full yellow, for pen knives.

At 49o degs., brown, for scissors and chisels, for cutting iron.

At 51o degs., red with purple spots, for axes and plane-irons.

At 51o, purple, for table-knives and large shears.

At 55 degs., bright blue, for swords, watch and bell springs.

At 56o degs., full blue, for daggers and fine saws.

At 6oo degs., dark blue, or almost black, the softest gradation for hand and pit saws.

Steel, if heated still further, becomes perfectly soft.

The ordinary bar iron of Sweden and England, when converted by cementation into steel, exhibits upon its surface numerous small warty points, but few or no distinct viscular eruptions; whereas the Dannemord and the Ulverstone steel present, all over the surface of the bars, well raised blisters, three eighths of an inch in diameter, horizontally, but somewhat flattened at the top. Iron of an inferior description, when highly converted in the cementing-chest, becomes gray on the outer edges of the fracture; while that of the Dannemord acquires a silver color and lustre on the edges, with crystalline facets within. The highly converted steel is used for tools that require to be made very hard; the slightly converted, for softer and more elastic articles, such as springs and sword blades.

One of the greatest improvements which this valuable modification of iron has ever received is due to the late Mr. Josiah M. Heath, who, after many elaborate and costly researches, discovered that, by the introduction of a small portion, one per cent., and even less, of carburet of manganese into the melting pot along with the usual broken bars of blistered steel, a cast steel was obtained after fusion, of a quality very superior to what the bar steel would have yielded without the manganese, and, moreover, possessed of the new and peculiar property of being weldable either to itself or to wrought iron. He also found that a common bar steel, made from an inferior mark or quality of Swedish or Russian iron, would, when so treated, produce an excellent cast steel. One immediate consequence of this discovery has been the reduction of the price of good steel in the Sheffield market by from thirty to forty per cent., and likewise the manufacture of table-knives of cast steel, with iron tangs welded to them; whereas, till Mr. Heath's invention, table-knives were necessarily made of shear-steel, with unseemly wavy lines in them because cast steel could not be welded to the tangs.

So great is the affinity of iron for carbon, that in certain circumstances, it will absorb it from carburetted hydrogen, or coal gas, and thus become converted into steel. Mr. Mackintosh, of Glasgow, obtained a patent for making steel. His furnace consists of one cylinder of bricks built concentrically within another. The bars of iron are suspended in the innermost, from the top; a stream of purified coal gas circulates freely around, entering below and creeping slowly above, while the bars are maintained in a state of bright ignition by a fire burning in the annular space between the cylinders. This steel

so produced is of excellent quality; but the process does not seem to be so economical as the ordinary cementation with charcoal powder.

All the artificial alloys of silver with steel, of which so much has been said, are not fit for any thing, and are never met with in commerce.

MANUFACTURE OF BAR-IRON.

Mr. W. Clay, of Liverpool, has patented some improvements in manufacturing bar-iron; that invention relates to the employment of rolling pressure for the conversion of bar-iron of various sectional figures, as, for example, plain, straight, square bars, or bars of angle iron, or T or channel grooved or trough iron, into taper bars, or bars which, in their cross-section, gradually diminish or increase from one point of their length to another, the object being to impart to bars of iron so made different strengths or powers of resistance at different points, and thereby to adapt rolled metal to various uses, where greater strength or rigidity is required at one point than at another. This invention also relates to the adaptation of rolling pressure to the formation of bars with sudden as well as gradual irregularities of depth or thickness, by which means it is proposed to form projections, protuberances, or indentions on or in the bars at different points, according to the particular purposes for which the iron may be required. Instead of allowing the top roll to rise gradually in its bearings, and thus afford increasing space between the rolling surfaces (as in his patent of Dec. 16, 1848), Mr. Clay adjusts the rolls to the work they have to perform, and keeps them to that position until the operation is completed, his object being to produce a class of work, the irregularity in the section of which is too great to permit of its being manufactured with facility by the rising roll process. For forming a taper on the extremity of bars suitable for railway "points," he sets the rolls to a distance apart that will correspond with the greatest depth which the formed bar is required to measure, say, for example, three inches; and assuming also, for example, that the extremity of the bar is to be tapered down to, say, one inch in depth, he provides a plate of iron or steel of a taper form, and of a thickness corresponding exactly with the diminution of thickness required in the end of the bar under operation. This plate he takes, in its cold state, and places over the end of the bar of red-hot metal, and then passes the two between the rolls. The taper plate acting as a filling piece, or as an eccentric projection on one of the rolls would act, enables the rolls to put a severer pressure on the bar at the part overlaid by the plate, and thus by simple rolling in an ordinary rolling mill a tapered bar may be produced.

The application of this principle of rolling may be further extended by giving to the contact face of the overlying plate such projections or indentations (whether gradual or sudden) as circumstances may require, such projections or indentations corresponding to, or rather forming a counterpart of the figure to which the contact surface of the bar is required to be reduced. A plate thus formed, being placed over a heated bar of metal, and submitted with it to the pressure of a pair of rolls, will leave the counterpart impression of its face upon the heated bar of metal. In like manner, when projections or indentations are required on opposite sides of the bar, as will be the case when rolling the spokes for railway wheels, Mr. Clay proposes to enclose the metal to be rolled (the same having been previously heated) between two suitably shaped pressure plates, and then to submit the pile to the rolling pressure.

In this way it will be obvious that he can reduce to unequal thicknesses not merely flat bars or plates of iron, but also angle iron and metal bars, having a concave or convex surface. The patentee claims the imparting a rolling pressure to the bar-iron, in the manner and for the purpose above set forth.

ON THE FORMATION OF BRASS BY GALVANIC AGENCY.

Copper is more electro-negative than zinc, and separates more easily from its solutions than a metal less negative. If then, in order to obtain a deposit

of brass by galvanic means, we employ a solution containing the two component metals, copper and zinc, in the proportions in which they would form brass, there will only be produced by the action of the battery a deposit of real copper; the zinc, more difficult of reduction, remains in solution. What must be done, then, to obtain a simultaneous precipitate of the two metals in the proportions required, is either to retard the precipitation of the copper or to accelerate that of the zinc. This may be accelerated by forming the bath with a great excess of zinc and very little copper.

Dr. Heeren gives the following proportions as having perfectly succeeded:

There are to be taken of		
	Sulphate of copper	1 part.
	Warm water	4 "
And then	Sulphate of zinc	8 "
	Warm water	16 "
	Cyanide of potassium	18 "
	Warm water	35 "

Each salt is dissolved in its prescribed quantity of water, and the solutions are then mixed; thereupon a precipitate is thrown down, which is either dissolved by agitation alone or by the addition of a little cyanide of potassium; indeed, it does not much matter if the solution be a little troubled. After the addition of 250 parts of distilled water, it is subjected to the action of two Bunsen elements charged with concentrated nitric acid mixed with one tenth of oil of vitriol. The bath is to be heated to ebullition, and is introduced into a glass with a foot, in which the two electrodes are plunged. The object to be covered is suspended from the positive pole, whilst a plate of brass is attached to the negative pole. The two metallic pieces may be placed very near.

The deposit is rapidly formed if the bath be very hot; after a few minutes there is produced a layer of brass, the thickness of which augments rapidly.

Deposits of brass have been obtained in this way on copper, zinc, brass, and Britannia metal; these metals are previously well pickled. Iron may, probably, also be coated in this way; but cast iron is but ill adapted for this operation.—*Mittheilungen des Hannov. Gewerbevereins*, through *Dublin Journal of Industrial Progress.*

IMPROVEMENTS IN SMELTING, AND IN APPARATUS TO BE USED THEREIN.

By William Truran, *of Marazion, Cornwall.*

In his improved method of smelting, the patentee divides the internal bore of the blast nozzle or nozzles in such a manner that it or they shall deliver a divided jet, or two or more jets of blast, into the interior chamber through the same tuyere; the pressure, temperature, and general qualities of the blast delivered by the respective jets being either alike or dissimilar, as may be advisable, and of such form and relative proportions as the peculiar circumstances of the furnace and materials may require. The throat and mouth of the interior chamber, through which the decomposed blast escapes into the atmosphere, and of so much of the interior chamber as lies above the boshes, is constructed of a breadth equal to or in excess of the breadth of the chamber at the upper bosh line, and of an area in the plane section equal to or in excess of the area at the upper bosh line.

The form of the jet and the intensity of the blast delivered by the respective divisions of the divided nozzle-pipe may be varied by substituting other nozzles differently divided, and the general dimensions of the nozzle likewise may be adapted to local circumstances; but it is preferred to form the nozzle of two cylindrico-conical cases of different size, the lesser being inside the larger, and maintained in its position eccentrically or concentrically, as may seem best, by suitable connecting pins or pieces—care being taken that such connections do not materially impede the delivery of the blast. When it is desired that the blast issuing from the circular central orifice shall be of equal

pressure and intensity with that issuing from the annular orifice, the proportion of taper, if any, in both inner and outer cases may be nearly similar.

By means of the improvements herein described, iron ores are smelted with greater economy of fuel, blast, and other materials than heretofore, and iron ores of every description are smelted with raw or uncoked coal, which hitherto has been coked before use in the blast furnace; and iron of fine quality is produced without passing the ore through the preliminary operation of calcination, which has not heretofore been accomplished with the ores known to geologists as the carbonates of the coal formations, and to practical smelters as the clay band and black band iron stones.

SANDERSON'S PROCESS FOR REFINING AND IMPROVING THE MANUFACTURE OF IRON.

The object of refining iron is to deprive it of the deleterious matter it may contain, and also a portion of its carbon. To effect this, the usual plan is to melt pig-iron upon coke, with the addition of a strong blast, the oxygen of which acting upon the fluid iron, which is mixed with the various alloys, oxidizes them,and during the time necessary to decarbonize the metal a quantity of slag or cinder is formed, containing from 60 to 70 per cent. of iron, thus causing a great waste of metal, varying from 2 to 4 cwts. per ton. Besides this loss, the metal so produced is not uniform in quality, sometimes being too much blown and at other times too little, thus affording no means of obtaining a regular quality of malleable iron. Coke is used as a fuel, which is expensive, and the necessity of using a strong blast increases materially the cost of production. The objects of this process are—

1. To reduce the loss of metal, and to use coal as a fuel instead of coke.
2. To effect a uniform decarbonization of pig-iron without the aid of blast.
3. To use a chemical re-agent capable of giving out oxygen during its decomposition, which taking up and uniting with the carbon evolved from the metal produces carbonic oxide gas, which acting upon the earthy compounds contained in the pig-iron, precipitates the metal contained in them.
4. To effect a greater facility, and also to produce a greater economy in the cost of manufacturing refined metal, by decarbonizing it, and at the same time clearing away the unreduced or earthy matter with which pig iron necessarily becomes mixed during its descent through the blast-furnace; and, further, to effect an economy (by using a purer metal so obtained) in the manufacture of malleable iron, causing less waste in puddling, and also in the subsequent re-heating required for producing bar, rod, or sheet-iron.

The furnace used is a common reverberatory, having a bed large enough to contain 2 to 8 tons, or even more of fluid metal.

The crude iron may be operated upon either by melting pig-iron upon the bed of this furnace or by drawing it direct from the blast-furnace. When the metal is melted and at rest, the slag must be skimmed from the surface, and a chemical re-agent is then added, capable of disengaging oxygen during its decomposition. Carbonic acid, or carbonic oxide gases, will be produced by the decomposition of this substance, and by the union of the oxygen contained therein with the carbon contained in the fluid iron from which it is eliminated, the gases so produced being unable to re-enter the metal, either pass off in vapor, or act upon the silicates or other earthy compounds which the crude iron may contain, precipitating the metallic part and allowing the earthy matter to flow away as slag, containing comparatively but a very small percentage of iron. Thus, by adding such chemical re-agent, which by its decomposition will evolve elements capable of combining with the carbon contained in the iron, and of producing carbonic oxide gas, which, acting upon the earthy compounds or other deleterious matter contained in the iron, causes such deleterious substances to separate from the iron, obtaining very clean, pure, crystalline metal, capable of being manufactured into superior malleable iron.

Many hundred tons have already been refined by this process direct from the blast furnace, and also by re-melting the crude iron; in both instances the

result has been uniform—the loss in metal not reaching 100 lbs. per ton upon re-melted iron, or 60 lbs. upon that operated upon in a fluid state from the blast-furnace. The malleable iron is also very materially improved in quality, being entirely freed from red shortness, and when broken cold presenting a clean, tough, elongated fibre. The loss in puddling averages 84 lbs. per ton, taken upon a furnace working 12 days; and a proportionate waste is experienced in the mill furnaces, according to the kind or size of iron required. For producing a variety of castings, it has also been found very useful, giving them greater strength, arising from the discharge of the earthy matter contained in the pig, and bringing the metallic particles in close contact.—*London Jour.*

PROGRESS OF THE IRON MANUFACTURE.

We have before us the "Address of the Western Iron Association," organized May 18, 1856, in Cincinnati, for the purpose of exciting mutual interest, and communicating information among those interested in the iron manufacture. We notice in this some of the more interesting portions of it:

Looking to the magnitude and increase of the production of American iron we have the following results, viz:

In 1840, the production of American Pig Iron was	286,903 tons.
In 1850, " " "	563,755 "
In 1855, " " "	900,000 "
Increase from 1840 to 1855,	225 per cent.

This is *sevenfold* the increase of American population, yet it is not so rapid as the importation of foreign iron, which in the same period was about 300 per cent. These facts show a most remarkable state of things; that the increased consumption of iron, from new uses, is so very great, that no increase of production, however great, has been able to keep pace with it. This does not prove the inability of the American manufacturer to supply the demand, for his resources are inexhaustible, but does prove that, for many years to come, the *demand for iron will be sufficient to secure a ready market and good profits* to the American producer. This is a very satisfactory conclusion to all persons engaged in that business, and one which may be relied on. The following aggregate of iron consumed in the United States, at different periods, will prove the general proposition yet more conclusively:

In 1840, total consumption,	411,903 tons.
In 1850, " "	1043,929 "
In 1855, " "	1810,000 "

This shows an aggregate consumption equal to an increase of 250 per cent. in 15 years—a ratio altogether beyond the increase of the population, or of any other great interest in the country.

From this general view of the subject, we may turn to a more special examination of the iron business in our own immediate vicinity. The first column in the table shows the increase of the furnaces in Ohio alone; and the second, in the Iron Region around Hanging Rock.

	Furnaces in Ohio.	Furnaces around Hanging Rock.
In 1830,	12	4
In 1840,	21	23
In 1850,	35	45
In 1855,	50	56

We should have said that about 22 of the furnaces in the Hanging Rock region, or doing business at Portsmouth, are in Kentucky and Western Virginia. For a list of these we are indebted to Mr. Conway, of Portsmouth. That gentleman has also furnished us with the statistics of each furnace, the aggregate of which is as follows, viz:

Furnaces,	56
Metal produced, at 2,000 tons each,	112,000 tons.
Value at $85 per ton,	$8,920,000
Number of men engaged,	5,500
Population, (5 to each man,)	27,500
Grain consumed,	1,100,000 bushels.

Taking into view, all the incidental branches of business necessary to support such a population, we cannot suppose that less than 50,000 persons are dependent on this branch of business, or nearly one thousand to each furnace. Pursuing the pig metal, into blooms, bar, and rolled iron of all description, we find that the value of manufactured iron, produced from these 56 furnaces, amounts to *six millions of dollars.*

Let us pursue this business a little farther—descending to Cincinnati, and examining the callings, business, and population to which iron gives rise, we may here add, that although Cincinnati consumes nearly all the pig iron raised in the Hanging Rock Region, yet she also consumes iron, from Pittsburg, from the Cumberland River (Tenn.), and even from Georgia. Hence, Cincinnati concentrates a great, profitable and important business in iron.

The following are the statistics of iron manufactured in Cincinnati for 1855.

Hands employed,	6,000
Population,	30,000
Population dependent on the business,	50,000
Value of Manufactures,	$6,000,000

These manufactures of iron are sold in every town and hamlet of the Mississippi Valley. They consist of every possible article fabricated of iron. To give some idea of this business, we state, that in one manufactory, there are not less than *one thousand varieties* of articles made from Iron!

This business is not likely to be diminished, by any changes, in the commercial world. It does not depend on fashion, but on necessity; the wants and uses of civilization. Hence, the American manufacture of iron will go on with increased vigor.

JOURNAL OF GOLD MINING OPERATIONS.

CALIFORNIA GOLD FIELDS.

Quartz Mining in Grass Valley.—We have been permitted to examine a memorandum of one of the principal mills in this district, which shows a gross amount of 1452 tons crushed, yielding an aggregate of $82,500, taken from thirteen different veins within two and a half miles from this place. The rock was crushed in 27 different parcels. The average yield per ton is within a fraction of $57. We noticed among the parcels that the highest yield was $370 per ton, one $180, and several of a hundred and upwards. The lowest yield of any one parcel was $23. The value of the gold is estimated at its market value in this place.

We learn that Messrs. Judd, Watts and Keefe, had 170 tons of rock crushed at the Gold Hill mill, last week, which yielded them $19,700—within a fraction of $116 to the ton. The cost of raising and crushing this rock will not vary much from $16 per ton, leaving a net profit of $100 per ton; or a gross amount of $17,000 on the entire lot! The same parties have another lot of about the same quantity already on the surface, which it is thought will pay

equally well or better than the above. This rock was taken from Massachusetts Hill, adjoining claims of Rocky Bar Company. The same parties have 150 tons from the Sebastopol ledge, now being crushed, which it is expected will yield over $100 to the ton.

Messrs. Judd & Co. hold a lease of the claim on Massachusetts Hill which has yet three years to run. If it continues to pay at this rate for the entire time of the lease, the lesses *ought* to become rich men. The proprietorship of the ground rests in Mr. Joseph Woodworth, of this place, who receives as a condition of the lease (or what is termed a royalty) one fifth of the gross products.

Grass Valley may well afford to dry up her Placer diggings, as long as she possesses such quartz mines as these. The business of quartz mining in this place never was so prosperous as at the present time. The business is now fairly under way, and immense fortunes must be realized within a few years of the present time.

The above will give some idea of the extent and value of the quartz mining interest of Grass Valley, and in fact of the entire State; for we presume there are many other locations which, if facts were collected, would exhibit results nearly, or quite equal to the above. The quartz veins generally of California, are of limited extent, and narrow, but they are found every where from the summit of the Sierra to its foot hills, and in many localities on the Coast Range. An entire century even will make but small progress in revealing their numbers and richness.

The reader, on a perusal of the above, cannot fail to notice the large yield per ton of the veins of California, when compared with the produce of other mines. Our article in this issue, on the Moro Velho mine in Brazil, will enable the reader to institute a comparison between it and the mines of California. In a future number we shall give some description of the mines of Russia as developed in the Ural mountains, and as fast as we can collect the facts from other mines in various parts of the world.

QUARTZ MINING SUMMARY.

Each successive month adds largely to the interest and extent of quartz mining in California. Scarce a mail arrives that does not bring us some reports of new and valuable discoveries in this branch of mining. The difficulties and delays attendant upon placer mining by reason of the insufficient supplies of water and limited extent of placer diggings, are having the effect to turn the attention of great numbers of our mining population to that sure and more permanent source of wealth the quartz veins. It is now becoming very generally understood that every man may, if he will, possess a gold mine of his own, and a mine too upon which he can settle down permanently, with his family about him, if he chooses, and find in one locality employment for a lifetime and his children after him. In every portion of the State, resting upon the western slope of the Sierra Nevada, and in many places upon either slope of the Coast Range, gold-bearing quartz veins exist unlimited in numbers, and in their general average of richness far exceeding any similar deposits on the globe. Never, until the mountain ranges themselves are brought down to a level with the plains, will the gold which they contain be exhausted. The placers may in time become worked out, but the gold-bearing quartz *never.* The time is not far distant when almost every valley and gulch throughout our mountain ranges will resound with the clank of the iron stamper, and where we now count our quartz mills by dozens they will be numbered by hundreds.

Our "Summary" for the past month is full of encouragement for the present and hope for the future.

Butte County.—Quartz mining in this county, says the North Californian, has been rather in disrepute until within a year past, since which time, and particularly within six months, a very considerable degree of attention has

been attracted towards it. During the last few months work has been recommenced on several old ledges, and many new ones have been discovered. Quartz claims are now held in high estimation, and the quartz business is looked upon as the chief source of the future prosperity of the country.

The only steam quartz mill in the county is that owned by the Spring Valley Q. M. Co. which runs eight stamps, and to which arastres are now being added. This mill was erected in 1852, but has remained idle most of the time since until within a few months. The facilities of the company for raising, transporting and crushing their rock are such as are not often surpassed.

We believe there is also a mill near Cherokee Flat, another owned by Beaumont & Gummet on Oregon Gulch, and one owned by Smith & Parks at Columbiaville. The latter are running six arastres, and have a very excellent vein, toward which they are running an adit, at great expense, which has already been driven 800 feet.

Several companies are at work on different ledges with arastres, some of which are doing remarkably well. Nesbit & Simmons have four arastres in operation, and have an excellent ledge. White, Nutter & Co., run two arastres, which are paying largely. Messrs. Derrick & Co., are also running two arastres, with good results. These companies are all, we believe, in the vicinity of the Feather River Table Mountain, about twelve miles northerly from Oroville.

Mr. J. H. Dubois, Messrs. Briggs, Crawford & Co., and Messrs. Williams & Packard, have lately discovered and opened what so far appear very valuable veins.

Nevada County.—Three new mills have been commenced in Grass Valley the past month. One by Messrs. Layton & Rush, on Wolf Creek, directly opposite the Empire mill. Eight heavy stamps will be put in, which will be driven by steam. The mill will be pushed forward with all possible diligence. Messrs. L. & R. have been among the most successful quartz operators in Grass Valley, and we are pleased to note their determination to remain permanently among us, and contribute by their industry and capital to the further development of the resources of this place.

The second by Messrs. Woodworth & Co., on the Wisconsin lead, near Allison's Ranch, which will also be driven by steam and will run six stamps. This mill will probably be in operation in about four weeks. They have an extensive and very promising ledge. The engine and all the castings of this mill are to be made in Grass Valley, at the foundry of Messrs. Dickenson & Clarke. The mill is located directly upon the vein.

The Mount Hope Co. (formerly Rocky Bar) have determined to remove their present engine and pump from where it is now located to another portion of the vein, where it is needed, and supply its place with a much larger pump, and an engine of sufficient power to drive a set of stamps, which will be forthwith erected on the site of their present works.

The new works in process of erection at Allison's Ranch are about completed. The shaft has already been driven to the depth of eighty feet. We anticipate some splendid results when they commence taking out rock from their shaft. This company do not propose to erect stamps at present, but will haul their rock as heretofore to some other locality to be crushed.

The mills generally in this place are doing well. We have elsewhere made mention of some important results of quartz mining in Grass Valley, which have been developed during the past month.

Placer County.—A correspondent of a Placer paper, writing from Doty's Flat, says:—"At the present time quartz mining is receiving considerable attention in this vicinity, and so far has been very successful and remunerative to those engaged in it. We have now some twenty arastres in successful operation, but they have not yet fully tested the various leads they are working. The three belonging to Messrs. Jeffry & Cox were cleaned up on Saturday last, after being run six weeks, and yielded twenty-six hundred dollars,

The quartz was taken from a ledge running east and west on the dividing ridge between Ophir and Doty's Flat."

Much of the quartz in that neighborhood pays from $50 to $60 a ton.

We understand there is a new mill in progress of erection about a mile north of Oro City, in this county, but have not learned the names of the proprietors.

In the vicinity of Oro City, near Auburn, a great number of arastres have recently been erected, to test or work many of the veins. Some fifteen or twenty are already in operation; and many more will soon be put up. Some of them are paying very largely. From one near Gold Hill 40 oz. of gold was recently taken, the result of five days' work from selected rock. Our informant assures us that 400 lbs. of rock per 12 hours is an ordinary day's work. They are driven by mule power,and usually put up in clusters of three or four. One man, standing in the centre, can easily feed and attend to four. Four arastres will reduce 1600 lbs. of quartz, which with rock that will yield $25 per ton, is very good pay.

By a letter from one of the proprietors of the mill at Sarahsville, in this county, forwarding us a number of subscribers for the Journal, we learn that the Company there is doing very well. They use the *revolving stamps*, of which they have twelve, weighing 480 lbs. each. They started in July last, and have been running regularly, day and night since that time, with very satisfactory results. Accompanying their letter was a couple of specimens from their vein. The *specimens* certainly present a very fine appearance, and give indications of a very rich lead. We have placed them in our cabinet.

El Dorado County.—The Placerville American of June 21, says: "Dr. Stanley has been successfully engaged in quartz mining at Grizzly Flat for the last four years. Commencing with but little means, he has gradually worked himself into an extensive and lucrative business, and will soon have largely extended arrangements completed for a still more vigorous prosecution of his enterprise. And yet, with no desire of monopoly or exclusiveness, he frankly asserts that other opportunities of equal promise lie open and unimproved in his immediate neighborhood, for such as have the enterprise to seize upon them. Although three new mills will be in operation next fall, it can hardly be said that even these will lessen the chances for still further equally promising investments in the immediate vicinity of Grizzly Flat, in this county."

Calaveras County.—We learn that the proprietors of the famous Carson Hill mine, in this county, Messrs. Roe, McLane & Co., are now engaged in the erection of a mill upon their lead. They are putting up a mill with a capacity sufficient to reduce 25 tons per day. Will use stamps and arastres. This mine is one of the most celebrated in the State. It was opened in 1851. Soon after its discovery it was leased to a party of Mexicans who worked it at halves. $406,000 were divided the first year. Since that time the proprietors have been trying to negotiate for its sale to a company of foreign capitalists. They have been unable however to make satisfactory terms, and have now concluded to put up machinery on their own account. One of the proprietors was in Grass Valley recently for the purpose of witnessing the plan of our mills and the mode of working adopted here.

We learn that the mill near Mokelumne Hill, in which Samuel Purdy, late Lieut. Governor, is largely interested, has recently been started up anew under flattering auspices. About $20,000 were taken out in the month of May. The mill until recently has been idle since 1852. We should be pleased to be put in possession of the name of this mill, with the Directors, &c., so that we may enter it in our "Mill Directory."

Messrs. Clark & Gass are putting up a new mill at Rich Gulch, five miles from Campo Seco. Their machinery arrived on the ground a few days since. They have a very promising vein from which good returns are expected.

Tuolumne County.—One of the papers published in this county, says: "It is with pleasure that we notice some of our foremost citizens turning their attention to quartz mining. Developments that have generally been made

during the past two years, have clearly demonstrated that mining in quartz, in this county, if properly conducted, is likely to prove one of the most lucrative employments. We have many good veins, which need only be worked properly to add greatly to the wealth of the county.

We understand that Messrs. Heslep & Co., are about constructing a quartz mill, on Wood's Creek about one mile below Jamestown, for the purpose of crushing the quartz from their mine in Quartz Mountain, which has proven to be very rich. The enterprise is no doubt a precursor to others, having for their object the development of our vast resources.

Amador County.—Our friends in Amador have not kept us posted with regard to their progress the past month. We have merely incidentally learned that they are doing well there as usual, but are greatly troubled for lack of water. Amador stands second to no county in the State, except Nevada, in her quartz mines.

Santa Cruz.—A very important quartz discovery has been recently made in this county, which promises remarkable results. About a year since a party engaged in working upon the banks of a small stream in this county, about six miles from Santa Cruz, accidentally discovered beneath the roots of a large tree a highly auriferous quartz vein very much decomposed. A company was formed and a mill erected, which was put in operation last spring. The rock has proved very rich, and has stimulated farther researches, until it is now ascertained that a region of gold-bearing quartz exists for some ten or twelve miles in length by three in breadth, which according to the Santa Cruz Sentinel, from which we gather these particulars, is traversed throughout its whole extent with innumerable veins, some of which are known to be exceedingly rich, and all of which contain more or less gold. The Sentinel gives a list of 23 Companies which have taken up claims in this district, several of which have made very considerable progress in the development of their claims. The gold obtained from this region is heavily alloyed with silver, and is worth only $13 50 per ounce. We shall watch with considerable interest the further development of this new mining locality.

PLACER MINING.

The present has been throughout the State generally, a season of unparalleled prosperity among miners. Water was never more abundant or cheaper. Immense operations are going on all over the State in hydraulic and other washings, and every where with the most favorable results. The miners in all directions are gathering golden harvests of the precious ore. The immense reservoirs of snow which have been piled up among the mountains the past winter, are just beginning to liquidate beneath the genial rays of a summer sun. Notwithstanding the labored efforts in certain quarters to prove to the contrary, there can be little doubt that the recent heavy shipments of gold are mainly attributable to the fact of its greatly increased production. We regret that we are compelled to make our own neighborhood almost the only exception to the general rule of prosperity in placer mining. Grass Valley at the present time seems to be most unfortunately situated. With immense auriferous placer deposits all around us, known to be rich, we are still almost totally deprived of that indispensable element of prosperity to the miner—water. The worst feature too in the case is, that there is very little prospect of immediate betterment of our condition in this respect. Many have looked with earnest hope to the construction of the South Yuba Canal, as a source of supply. That work is now rapidly drawing towards a completion, but we are told by the managers of the concern that it will be useless for Grass Valley to look to them for a supply of water. It is considered doubtful even whether Nevada will be to any considerable extent directly benefited by the enterprise. So rapid has been the development of the mineral resources of the country which is traversed by that ditch, it is thought now that the entire quantity of water taken from the Yuba by it, though filling a canal six

feet wide by four deep, with a large fall, will be needed by the miners above Nevada. Of course it will be the aim of the proprietors to dispose of their water to the nearest buyers, as the further they carry it, the greater their loss by leakage and evaporation.

In view of these facts, it behooves the citizens of Grass Valley to make some other arrangements to secure the needed supply. We have heard a number of projects mooted, but nothing seems to be done beyond *talking* about it. Will not some one make a determined move in the matter. We have men among us whose property and business would be doubled in value by the introduction into our town of a plentiful supply of water. We have surveyors and engineers who are abundantly able and competent to make the preliminary surveys, and to carry on the work to a successful issue. Will not our property men take hold of the matter? If an early move is made, water can be obtained; if we delay much longer, the water which at the present time is free will be diverted to other channels, and the opportunities which are now presented will be lost for ever, at least to the present generation. Again we ask who will move in the matter? We pause for a reply.

AN EXTENSIVE FLUME.

An extensive Flume.—Mr. A. S. Hart & Co. have purchased the river claim in front of the town of Oroville, Butte Co., and are about to commence turning the river at a point nearly opposite the Orleans Hotel. The flume will be thirty-five feet wide, six feet deep, and three thousand feet long—probably the most extensive in the State.

KENT'S APPARATUS FOR SEPARATING GOLD.

Patented in the United States, Great Britain, France and Belgium.

Shortly after entering upon my official duties as Melter and Refiner in the United States Assay Office, it was my ambition to discover a more effectual method for separating gold and silver from foreign substances than any which had been hitherto employed. Having an abundant and constant supply of material, I had facilities for effecting this object, which enabled me to investigate the subject in the most thorough and practical manner. The result of this investigation was the invention of the apparatus herein described, the first of which has been constantly in use at the United States Assay Office in New York, since August 1st, 1855. One of them has been subsequently introduced into the United States Mint at Philadelphia, where it has been in daily use since April 1st, 1856.

The most striking peculiarity of this invention is, that so large a proportion of the gold can be separated by specific gravity alone. During the first six months of its use 9,333.66 ounces of gold and silver were separated by it, and of this large amount, 9,110,66 ounces (which is 97.6 per cent, of the whole) were obtained from the "Separator," which is that portion of the apparatus in which the separation is effected by *specific gravity* in a high column of water, without the use of mercury. The specific gravity of quartz is 2½, iron pyrites 5, and of gold nearly 20. The finest particles of the precious metal are, therefore, nearly eight times heavier than those of quartz, and four times heavier than those of iron pyrites. Consequently when these, or other substances containing gold, are suspended in a high column of water, the gold which is the heaviest, falls to the bottom, and with a gentle current of water passing through the apparatus, the earthy substances, which are lighter, and the sulphurets, when re-crushed sufficiently fine, are carried away, and the gold remains.

Although gold is nearly twenty times heavier than water, it will sometimes float upon the latter, and is then called "floating gold." This is due to a repulsion of the fine particles of gold and water, which temporarily overcomes

the law of specific gravity; but it occurs *only* when the gold is *dry* on the surface. If a needle be wiped dry and placed lightly on the surface of water, this also will float, and become a "floating needle;" but let the fine particles of gold or the needle, *become once wet*, they will each obey the law of specific gravity, and fall to the bottom.

The principles involved in the action of the "Gold Separator" are based upon the theory described above. The ore (which has been previously crushed as fine as possible) is first *agitated with water*, by feeding it into the hopper or "Grain Separator," in which the gold which has been liberated by the previous crushing, is separated and retained. The earthy portion of the crushed ore is carried thence into the *centre* of the column of water in the submerged Chilian mill, in such a manner as to prevent the finest particles from floating upon the surface of the water, in which, as in the case above mentioned, the gold is separated and falls to the bottom, in obedience to the law of specific gravity. The heavier particles of earth or ore, *which are those containing gold*, also fall to the bottom of the mill, by virtue of their specific gravity, where they are ground under the water in which the finer portion is suspended by the agitation of the wheels, the gold falling to and remaining at the bottom, while the earth is carried away by the current of water; and as daily practical operation *has proved* nearly 98 per cent. of all the gold is thus saved by specific gravity alone, and without the use of mercury, by the "Gold Separator" above described.

The principles involved in the action of the "Amalgamator" are based upon the following theory:—It is well known that gold, *when clean*, readily amalgamates with mercury: but if the particles of gold, or the surface of the mercury, are dirty, there is a repulsion of the particles similar to that above mentioned, in the case of floating gold, and consequently dirty gold, *such as is found in all native ores, and particularly in auriferous pyrites*, cannot be entirely separated by amalgamation alone. Every gold miner will bear evidence to this. But dirty gold is nearly as *heavy* as clean gold, and consequently it can be separated by *specific gravity* upon the principles above mentioned; and when the particles of gold thus separated, and the surface of the mercury are both cleaned, as in this apparatus by the double action of wooden paddle wheels, the final separation of the gold may *then* be effected by amalgamation.

It is also well known to gold miners that when the mercury used for amalgamation is broken up, or divided into small globules, these cannot be made to reunite when dirty; and consequently a large quantity of mercury as well as gold is lost, in most of the amalgamators heretofore invented. With the apparatus herein described, this is not the case. The mercury is not agitated or broken up by stirring, and the high column of water above it prevents it from being carried away by the sand, consequently the mercury is saved in the same manner as in the separation or saving of gold by specific gravity. After six months daily and constant use of this amalgamator, no diminution of the quantity of mercury originally used was observed; and by carefully re-washing five barrels of tailings which had previously passed through it, only a trace of mercury was obtained.

It will be observed, that the earthy substance or crushed ore, when *once* supplied to this apparatus, is subjected to *three separate, distinct and successive operations*, all of which are based on scientific principles, and applied to the metallurgy of gold in the following manner:—

1. The crushed ore is first supplied to the hopper or grain separator, in which it is agitated with water, and subjected to an operation which very nearly resembles hand-washing or panning, which is familiar to all gold miners; but it is much more perfect than hand-washing, and instead of being performed by hand, is effected by the aid of machinery, so as to avoid manual labor, and perform a much larger amount of work. By this operation *alone*, all the gold that can be saved by hand-washing or "panning," is separated at once, without abrasion or loss.

2. The earthy portion, from which all the gold which can be separated by panning, is now removed, passes into the centre of the column of water in the submerged Chilian mill, where it is re-crushed under water, so as to liberate the *finer* particles of gold from the earth, and the whole being suspended in the high column of water, by the agitation of the wheels, the earthy portion passes off when ground sufficiently fine, while the gold falls to the bottom of the mill, by virtue of its greater specific gravity, and is saved in the form of very rich or highly concentrated ore, from which the gold may *then be profitably* separated by smelting.

3. The fine earth which passes from the mill is again suspended in another column of water, and the *finest* particles of dirty gold which are thus separated by specific gravity, are cleaned by the double action of the paddle-wheels, and *then* collected by amalgamation with the mercury, which is also cleaned at the same time, in such a manner as to prevent loss of mercury or the gold

This apparatus is not heavy enough for *crushing quartz*, and was not designed for that purpose. But it is particularly adapted for separating *gold from the sulphurets*, and this is the portion usually lost by the use of other apparatus. For these reasons, the crude ore should be previously crushed as fine as possible, by larger and more powerful apparatus; then concentrated in such a manner as to leave the sulphurets and *wash away the quartz.* The *sulphurets* which retain the precious metal are then to be supplied to *this apparatus for separating the gold.* By this process a large amount of ore or tailings may be worked daily, because the bulk of the rich sulphurets is small, compared with that of the quartz. If, therefore, twenty tons of the powdered ore, or tailings from other apparatus, contain but one or two tons of *sulphurets*, the *gold* from twenty tons of it may be daily saved by this invention.

MONSTER NUGGETS FOUND IN VICTORIA.

1. A pure nugget weighing 336 oz., called the Dascombe Nugget, from Bendigo. This nugget was shown to Her Majesty by Messrs. Herring, of London, to whom it was sent by Mr. Joseph Herring, gold broker, Melbourne. —May 31, 1852.

2. A pure nugget, weighing 340 oz., from Bendigo.—Sept. 18, 1852.

3. Monster nugget, or bar (from its shape), of gold, dug up within ten yards of where No. 1 was found, weighing 564 oz. The fortunate finders were from Adelaide. It was about 2 ft. long and 5 in. broad, entirely free from quartz, and shaped somewhat like a twisted or French loaf.—Oct. 16, 1852.

4. A lump of gold and quartz, weighing 1620 oz., found at Ballarat; was taken home in the steamer *Sarah Sands* by the finders, who came out in the *Great Britain* about ten weeks previously.—Feb. 5, 1853.

5. An 84 lbs. or 1008 oz. nugget, found at Fryer's Creek; shipped per *Lightning* in April, 1855.—April 7, 1855.

6. Nugget weighing 40 lbs. or 480 oz., found at Ballarat; shipped in *Red Jacket*, May, 1855.—April 7, 1855.

7. Nugget weighing 48 lbs. or 576 oz. found at Ballarat and shipped in *Red Jacket*, May, 1855.—April 28, 1855.

8. Splendid quartz specimen, weighing 24 lbs. or 288 oz. from Mount Blackwood; shipped in the *Red Jacket*, May, 1855.—April 28, 1855.

9. A nugget, weighing 88 lbs. 4 oz. or 1060 oz., found at Maryboro', or Simson's Ranges. This was melted into ingots, and turned out a losing speculation for the purchasers.—June 23, 1855.

10. A nugget, weighing 760 ozs., found near Old Daisy Hill; still in Melbourne.—Oct. 27, 1855.

JOURNAL OF COPPER MINING OPERATIONS.

LAKE SUPERIOR REGION.

The reports from the Lake Superior Region are generally of the most favorable character. The position of many of the mines is such that their intrinsic value will be more positively demonstrated this year than ever before. From recent numbers of the Lake Superior Journal and other sources we obtain the following facts:

The increased facilities for obtaining supplies, shipping the copper, and the experience already attained in "mining" are rapidly establishing this business upon the same basis of certainty which characterizes manufacturing and other pursuits. It is a business which requires experience and thorough investigation to be calculated with certainty.

This position is gradually being attained from year to year, as the mines are opened and developed, and the day is not far distant, when mining operations will be looked upon in the same light as mercantile or commercial business, and attended with no more risk or uncertainty than these. Experience will teach the miners how and where to expend their labor most profitably, and thus avoid all unnecessary expenditure, which now consumes the product, and sometimes more, of the mines. These facts in connection with the good reports from the mines leave no room for doubt as to the final issue.

The Central Mine will ship about 40 tons of copper this season, which, as their expenses are not heavy at the present time, will somewhat more than pay the current expenses of the mine. In the estimation of persons of competent judgment, the prospects of this mine are very flattering, and should present appearances continue, the stock of this Company will pay good dividends ere long.

The *Isle Royal* raised and shipped 203 tons during the nine months preceding August 1st, but the amount raised during June and July was something less than the estimates and expectation.

The *Rockland* is in the ascendant, and it is confidently expected that it will equal the Minnesota in a comparatively short time. Our latest report from the Garden City are of the most encouraging character, the "ash-bed" yielding richly in stamp work. We understand that on account of some legal difficulty, the operations at the Ohio location have been suspended, although the show of copper is excellent.

We learn from a gentleman just from the *North American* mine that it is doing remarkably well, having reached the "paying point." There are now employed at this mine 180 men, 96 of whom are miners, who are now getting out about 80 tons a month of stamp work and masses. They have shipped since the 1st of January last, 579 tons, and expect to ship in all the present season 824 tons. The same gentleman informs us that the *Cliff* continues to work well, and will probably ship 1500 tons this year.

At the *Mass Mine* they have lately uncovered a lode lying to the north of their main vein which shows remarkably well for regularity, and which we regard as a new feature of great value to the location.

We gather from the "Report of Chas. T. Harvey, Esq.," the following facts in relation to the *Norwich Mine.*

The first object of interest in proceeding to the Mines are "*road facilities.*"

In preceding years a road had been constructed from the Mine to the Ontonagon River at a point called the American Landing, distance ten and one-half miles, at a cost to your company, including a joint interest in the Landing Dock Warehouse, &c., of some $6,500. But little outlay is required (this sea

son) to keep it in suitable repair for the land carriage of copper and supplies which are transported from Ontonagon to the Landing in flat-boats, a distance of some twelve miles.

On arriving at the mine, the first features noticed were the "Surface Improvements." Unfortunately the Company lost the stamp-house and saw-mill by fire, on the 18th of April last, caused by a spark from the engine chimney igniting the roof.

It seemed evident from a view of the premises that it was expedient to rebuild the stamps without delay; and on receipt of advices from the Board on the subject, the Superintendent took energetic measures to replace them in the shortest time; and they will be ready for use about the first of September, probably. The engine boilers and most of the iron shafting, &c., of the old stamps will be re-used in the new, having received but little injury. Besides this building notice was taken of the appropriate dwelling house for the agent, a good log-house for boarding the miners; a convenient barn, kiln-house shops, store-houses, &c.

The interior of the mine was next very closely examined. The general plan for its extension has, of course, been adopted in former years, and is now in the main adhered to; but at present good ventilation is secured in the main sections of the mine, and the vein approached so far in advance of its removal by "stoping," by means of adits, shafts and levels, that the miners can now be kept more in "productive work" than at any previous season since its commencement. This was not the case, but precisely the reverse during the past year, owing to the special efforts made to realize copper during the crisis in mining affairs in the winter of 1854—5. This circumstance should be borne in mind in contemplating the reduced products of the mine in 1855, and is a strong reason to hope better things for 1856.

The Norwich Mine has been worked up to this time without any other than horse elevating power—longer probably than any other of the same promises on the mineral range.

The lower level of the mine is 140 feet below the adit, and 350 feet below the present horse power, and the necessity for steam power is now imperative. With the approbation of the undersigned, Mr. Davis, superintendent, concluded to purchase a twenty-five horse power engine and boilers, newly made, then for sale at Ontonagon, and costing, with the gearing for a saw-mill, about $3,000. This will, it is believed, be in operation at the mine by the middle of August, at a cost of some $4,000, and will be all the steam power required until the mine shall have doubled or trebled its product. The constructive features of the adits, levels and shafts are in the main good; and from the inspection of all the prominent mines, it can be asserted, that for convenience and economy of the mineral obtained from the mine, in kilns, stamps, &c., the arrangement and position of the Norwich mine is not surpassed by any in the Lake Superior District.

	Tons.	Lbs.
The mine produced from 1846 to 1851 - - - - -	1	1,800
During 1852 to April 1st - - - - - -	12	200
" 1853 - - - - - - - - - -	47	376
" 1854 - - - - - - - - - -	18	881
" 1855 - - - - - - - - - -	189	857
" 1856 to April 1st - - - - - -	108	1,200

The product for the month of April, 1856, was 12 tons of masses, besides the stamp-work after loss of stamp-house.

The stamps' product per month, Mr. Davis, "from reliable data," estimates at 4 tons per month for the last three months.

It may be remarked in reference to the above figures, that in 1854 only 20 miners were at work on an average, as this mine was crippled for supplies and means. In 1855, during the panic in mining affairs, the mine was worked with a view of getting out the greatest possible quantity of copper in the shortest time, and at the least expense practicable, hence good policy re-

quired more unproductive labor in the ensuing season to open the mine properly for continuous working.

At this date, the mine is brought up (in the opinion of those in charge) to a proper stage of "advanced opening," and was never in better condition than at present. It is also the general opinion of examiners, that the vein never looked more promising than at present.

Masses are seen in sight at Stope No. 2, 4th level; Stope No. 5, 4th level; Stope No. 2, 3d level; Numbers 3, 6 and 7, 3d level.

The undersigned examined particularly the lode as it appeared in the bottom of 5th level, and can testify that it was extremely rich in barrel and stamp copper. This portion of the mine must wait for the steam power to enable its further progress.

In view of the above facts, the undersigned will be disappointed if the mine does not exhibit this season a material increase over the product of any former year. It is not unreasonable to hope for a yield of say 200 tons (including the product of the stamp, estimated at 50 tons), in the year 1856—57. From the best information at hand the expense of carrying on the mine will be defrayed by the sale of 180 tons, at present market price.

The local management of the mine is under the control of A. C. DAVIS, Esq., Superintendent; and the undersigned takes pleasure in bearing testimony to the order maintained in, and economical administration of the affairs of the company by Mr. Davis, so far as his observation extends. He was the discoverer of the location, and has been its pioneer up to the present date, having devoted his time and energies for the last ten years in its development, and has met aud surmounted difficulties and dangers in that period, which it is difficult for those at a distance, and of a "settled country" to realize.

The Superintendent mentioned approvingly of the services rendered to the company by Mr. C. SHERWIN, as *Clerk*, G. HARDY, *Mining Captain*, A. C. FRAZIER, *Machinist & Engineer*.

The conclusions the undersigned would draw from the above facts relative to the mine, are, that the Norwich is among the *most promising* of non-divided paying mines; and that instead of feeling depressed by the past, the stockholders should feel encouraged for the future: and that the mine should be sustained and worked during the present year, with all the force and energy which a wise administration of available resources will permit.

NATIONAL MINE.

At the National they have been steadily opening the lower parts of the mine. The lower adit, No. 3, has been communicated throughout, laid with tram-way, and is now the principal thoroughfare for the underground business of the mine. The advantages which this affords them is very great. The great trouble and expense of hoisting to the surface is avoided, as the stuff after being thrown down is taken out through the adit on cars drawn by animals. Shaft No. 2, which is the most western, is sunk to a fourth level, and they have driven eastward some distance toward No. 1, which is also about down to the same level. They intend to drive that level at four points from the two shafts immediately, until the connection between the two shafts is made, when they will continue driving east and west. Adits No. 2 and 3 will also be continually extended east. So that it will be seen that they are pushing on their opening with great rapidity by going east and deepening the mine. They have already opened new ground enough to give room for about 30 additional miners, who will soon be at work taking down the vein. As soon as their fourth level is connected between the shafts, a further increase of force can be made. These will, of course, add very greatly to the copper product of the mine.

The new openings thus far fully sustain the character of the lode for bearing copper. They have stoped a little in the back of No. 3 adit, west of No. 1 stope and have found the ground very productive. The courses of copper seem to dip to the west about 20 feet in each lift.

There is room on the buff for a fourth adit, about 145 feet, or two lifts, below the present No. 3. It would go in at the surface about 650 feet to the west of the mouth of No. 3.—The valuable facilities afforded by this system of working the mine, as illustrated by their present openings, will probably induce the company to undertake the driving of this before long. The National will soon have a great amount of ground ready for stoping, and her product for another year will shown a great increase upon her past production.

MINNESOTA.

The Minnesota has at present more copper in sight than we have ever seen in any previous visit to that mine. The amount of pure native mineral now exhibited there is truly astonishing. Without stopping to consider points of ground which in other mines would be considered rich, we will at present very briefly call attention to the position of some of those immense things which require the labor of large parties of men for months to exploit.

In the counter-lode running between the south and conglomerate veins, which we noticed more in detail some months ago, they are still tearing off great masses about the adit level. This singular formation, in some of the levels might almost be said to be a continuous sheet of copper extending from lode to lode, and is likely to afford almost enough copper in itself to make a good mine.

In the back of the 20 fathom level, near the No. 7 shaft, and in the back of the 10 level, between shafts 5 and 8 (on the conglomerate load), there are great masses of undetermined limits. At the latter point is what the Cornishmen call "*a great boil of a thing*"—a huge, shapeless, snaggy mass, resembling in appearance the copper in the Cliff mine. It is stripped for a great extent. One sand blast of 20 kegs of powder was fired under it without starting it in the least from its position.

Several large masses have been disclosed in the 20 fathom level, about sixty feet east of No. 4 shaft. This ground came near escaping the attention of the miners. They drove by it on a good foot wall which at first was supposed to be the limit of the vein, but through which little horns of copper were observed projecting. The great number of these attracted attention, and they determined to break through the foot wall, when it appeared that they belonged to the conglomerate vein, and led at once to great masses of copper in that formation.

In the fifty fathom level, east of No. 4, which is below the junction of the two lodes, the openings have exposed very large masses going up and down.

One of the most favorable and auspicious indications at present to be observed in this mine is disclosed by the new openings at the extreme eastern part of the undeground works. For a considerable time their drifts in that direction went through dead and unproductive gound. But within the last few weeks they have again struck the copper-bearing belts, and are now opening ground which promises to be of the usual richness.

The openings of the mine have been kept well ahead of the stoping parties. In truth they now have room for many more men to work than their present machinery will accommodate. They are about procuring a third hoisting engine, which, when in action, will add materially to the product of the mine.

The Minnesota raised during the month of June 303,123 lbs. of copper; and the Rockland, 40,395 lbs. during the same month.

The stockholders and friends of the latter, may safely look for an increase of production for the present month.

ROCKLAND MINE.

The *Rockland* now have quite a mine opened, and henceforth will probably turn out a greatly increased amount of copper. They have very fine masses, some 270 feet east of No. 3, and east of No. 4 shafts, in adit level. No. 5 shaft which is the first one worked on the conglomerate lode, is already sunk con-

siderably below the adit level, and No. 6, on the same lode, to the east, is sinking rapidly.

The history of the first operations of this mine is quite instructive. It has been brought to its present advanced state of progress with great energy, with a tax upon the stockholders comparatively trifling. But we shall reserve a detailed account of the mine until a future number.

The *Adventure* raised during the month of June 26,656 lbs.—13 tons 656 lbs. of which about two tons was stamp work—with 13 underground men, and five at the stamps.

At the *Ohio* mine, works have been resumed on the tribute system, under the direction of M. Milton Mason, of the Adventure and Aztec mines.

Notice of the other mines mentioned above will be given in another number.

OFFICE OF THE ISLE ROYALE MINE, HOUGHTON, July 7th, 1856.

Editor L. S. Miner, *Dear Sir* :—From recent remarks through the columns of your paper, I infer that you would like to have an occasional statement from the various mines throughout the Upper Peninsula in regard to work done, expenses, production, prospect, &c. Believing that the publication of reliable statements and statistics of the kind will have a beneficial effect upon the business of Mining and the methods of conducting it, I send you an abstract of the cost of the various kinds of work done and the production of mineral at our mine for the past six months, which if you see fit to publish are at your service. There has been,

Stoped 282 cubic fathoms, at an average cost per fathom of	$22 68
Drove, 464¼ feet, at an average cost per foot of	9 50
Shafts sunk, 74¼ feet, at an average cost per foot of	15 89
Winze sunk, 62¼ feet at an average cost per foot of	9 50

The last two items include all charges for windlassing.

We have raised 119 tons, 293 lbs. of copper, or an average of 19 tons, 1715½ lbs. per month.

The average amount of copper per fathom is 845 lbs. 3-282.

Average number of men employed has been 159.

Average expenditure of all kinds, monthly, $6,190 23.

Yours respectfully,

W. E. DICKINSON.

At the *Windsor* we learn the stamp mill is in operation and working finely.

Norwich Mine.—The product for the month of June at this mine was 10 tons 500 lbs.—This, when we take into consideration the fact that they have no means at present of reducing their stamp work to copper (which averages from four to five tons per month of stamp copper). shows a handsome increase in the production of mineral. We are informed by the agent that the new stamp house is progressing rapidly, and that it will be ready for service within the next sixty days; when completed it will materially increase the production of the mine.

Cliff Mine.—We are indebted to the *L. S. Journal* for the following figures in regard to the workings and product of this mine for the months of April and May.

There was raised in April of

Mass copper	157,471 lbs.
Stamp work	63,070 "
Barrel copper	81,117 "
Total	301,658 "

*No. of men employed—miners, 230; surface men and officers, 229; total, 459

Stoped North on West Vein, 225 8-36 fathoms, and paid $22.50 per fathom.

Drifted 130 9-12 ft., and paid for the same $9.85 per ft.

The amount of copper raised and prepared for shipment in the month of May, is as follows:

Mass copper	169,078 lbs.
Barrel copper	49,740 "
Stamp work	63,948 "
Total	282,761 "

No. of men employed—miners, 225; surface men and officers, 208; total, 428.

Stoped 168 10–36 fathoms, and paid $22.81 per fathom. Drifted 52 feet, and paid for the same $9.66 per foot.

THE NEBRASKA MINE.

Returning from a visit to the mines on the Minnesota Bluff, we stopped at the Nebraska, and devoted several hours to the examination of matters in that locality. We cannot but think that the present indications there are of a character quite interesting. The bluff upon which the mine is situated is cut off from the parallel ranges of the Minnesota location by the Flint Steel Gap—a broad valley, which sinks several hundred feet below the points of the spurs which confront it on either side, and carries the river of that name in its lowest depression. On the western side of this valley the hills of the Minnesota range lie with great regularity and symmetry, indicating that disturbances have not been frequent since their original upheaval. Their summits and sides are notched, in only one or two places, in such a manner as to indicate to the miner where he may expect to find a *fault* or heaving of the vein in the ground beneath. These superficial indications of regularity have been fully sustained in all the underground works of the great middle bluff, upon which the principal mines are located, wherever openings have been made.

From occasional cursory observations of the range lying to the east of this river, we have hitherto held the opinion that the country there was of a character widely different, being much disturbed and shaken up, and without regularity, though still bearing abundant surface evidence of copper. The gap through which the above-named stream flows, we have generally regarded as the boundary line between the region of regular veins, like those of the National, Minnesota, Rockland, &c., and that of the promiscuous metalliferous beds, such as characterize the Adventure and Aztec locations. We are not now prepared to say that this view of the character of the region in question is not just; but the late visit to the Nebraska disclosed to us some new facts which had escaped previous attention, or have been established by the recent workings on that location.

No very considerable amount of mine work has been done, but openings have been made on three several veins, two of which have certainly quite a promising appearance. The drift adit in the end of the bluff is much the largest opening yet made. In pushing this on, it is probable that the vein had been lost for a considerable distance, the workmen having been led aside to the north by a cross vein or feeder, and by copper indications in the country. Hence the rich ground which was struck several weeks since, and which has already turned out considerable copper, was met with as soon as they got back upon the vein in its regular course, by curving the drift southwardly. At the end of this drift is a large amount of rich ground, which for the past month has been quite productive. The vein has spread to an extraordinary width, and the opening made by taking out the copper rock has assumed the form of a large gallery. The copper still in sight in this drift will probably fully justify them in extending the openings at this point.

But there are new matters to which our attention was more particularly directed in the examination of this location. It has long been known that the bluff, near the crest, was much marked by ancient works, and upon the line formed by one series of these a shaft has been sunk some 60 feet, a little under the top of the hill, near the eastern end of the location. This open-

ing disclosed very good ground, and yielded considerable copper. But operations here, as in all other parts of the location, were not pushed on during the winter, for want of supplies. And, in truth, it may be said that a vigorous prosecution of the development of this mine has not been an object of its direction and management. The vein upon which this shaft is sunk lies probably some two hundred feet south of that on which the drift is made. There are seven very distinctly marked ancient pits which appear to be on it, three or four of which have been pretty well cleaned out. They were cleaning a very remarkable one of these, a few hundred feet from the shaft above named, when we visited the location. It is 80 feet or more in length, and from 8 to 12 in depth, and forms at the eastern end a cave, the rock of the surface being left overhanging. The vein for this length is completely exposed, and its character is very good. It shows copper throughout, and in some places there is very good barrel work. No large mass is uncovered, but there are several small projecting horns of copper, which have been hammered by the ancient workmen. If this pit had been discovered upon a new location, it would probably attract great attention, not only on account of the copper now in sight, but from the general indications to be noticed. In the other pits along the bluff, which are apparently upon the same vein, small pieces of copper may be taken out with a pick, with very little trouble, and pounds have been obtained in this way, by a few minutes' labor. In almost all of them the vein is strongly charged with the green carbonate of copper. Small pieces of silver, too, have been found. In one digging, successive visitors, prompted by curiosity alone, had taken out pieces of copper until they had accumulated to fifty or sixty pounds.

In short, we believe the surface indications upon this vein are such as to justify serious attention and thorough exploration, and we are glad to notice that eight men are now engaged in clearing out and examining these pits.

The whole force at present is about 85 men. They need very little more surface improvement to enable them to accommodate such a force as will be sufficient to open and prove the mine. And we hope that a vigorous policy will be adopted in the prosecution of the work, as it is the only one which, in mining, can be truly economical.

The Windsor, we are informed by the Agent, is now looking very well, and promises a fair product for the future. The stamp mill was expected to be ready for operations the present week. We learn that the amount of stamp work already out of the mine is quite large, and, together with what they are constantly producing from the mine, will keep the stamps busy for some time to come.

The new vein of which we have previously spoken is improving very much as they descend in depth. They have commenced the sinking of two shafts on this vein, one of which is down 20 and the other 15 feet from the surface. The vein in the bottom of one of the shafts is full three feet wide, and carries considerable copper. One piece was taken out weighing 3 lbs. quite pure, and many others of smaller weight.

MERRYWEATHER MINING COMPANY.

New York, August 1st, 1856.

As Mr. Merryweather only arrived at the mine on the first of June, all his time was required to arrange the work for the summer. It was, therefore, impossible for him to have the yearly accounts ready to place before the Stockholders at the Annual Meeting, and whilst your Directors regret the delay, they are pleased in being able, now, to present you with the annexed report, showing the satisfactory progress of the work. The vein continues of the most regular character, producing in parts rich stamp work and lump copper; the rock is soft and excellent, is easily worked, and at much less expense than is usual in other mines. The work has progressed steadily, and seems now approaching a point, where several veins and feeders are gathering into one

main trunk lode, and it is expected, from the present indications, that in sinking 60 to 80 feet further, a great improvement in the richness of the mine will manifest itself.

The expenses of the management are small, the only salary paid is to the agent at the mine. A good farm has been cleared, and the crops are doing well. The buildings erected are substantial, and the roads are being gradually improved. A new road will be cut to the mouth of Black River, where the supplies will, hereafter, be landed. This will save thirteen miles in distance to the lake, and also some of the expenses, such as storage, commission, &c.' now paid at Ontonagon.

MERRYWEATHER MINE, July 17, 1856.

JAMES T. WATERS, Secretary—*My Dear Sir:*—From the accounts transmitted to you, you will see that the expenditures of the mine, to the 1st inst., amount to $14,981 35.

Of this sum there has been expended for mining,	$5,861 18
For surface work (teams, tools, implements, farm labor, teaming, road work, &c.),	2,856 27
For provisions (consumed at mine),	2,406 79
For furniture (bedding, stoves, cooking utensils, &c.),	442 89
For buildings (houses and stable),	590 24
For blacksmith shop (cost of iron, steel, charcoal, smith's wages),	1,112 88
For transportation (freightage of supplies up the Lakes),	680 90
For general expenses (wages of mining captain, travelling expenses of agent, stationery for office, &c.),	1,580 06
	$14,881 35

The mining work consists of two shafts 180 feet deep each, a level of 200 feet in length between them, and an adit of 254 feet in length.

The farm clearing comprises an area of thirteen acres. The buildings are, a house for the accommodation of twenty-four men, a smaller one for a family dwelling, a stable, a store-house, blacksmith shop and coal house, and a new boarding house, with office attached, recently constructed at an expense of $300, not included in the above sum.

The buildings now erected will accommodate a force of fifty men. They are constructed of logs, well floored and roofed with shingles, and are strong and durable.

The vein we are mining is large and regular. It is composed of spar with occasionally quartz and epidote, and presenting copper in small lumps and bunches, and in fine particles disseminated through the veinstone. The occurrence of copper is found more frequent as we descend, the lode for some distance from the surface being soft, much decomposed, and in places barren. At our present depth a number of small feeders are dipping in the vein from the north side, and enrich it with copper. We also find a large epidote vein well charged with copper, approaching from the south under the foot wall, and we may also expect it will soon join and add to the strength of the lode.

Several agents of the neighboring mines, and other gentlemen of experience in the mines of the country have visited our grounds, and they confirm our own favorable opinion of the vein and the character of the rock through which it passes.

Other veins of very promising appearance are found in the outcropping rock, but the force employed at the mine has always been too small to withdraw a part from the present work to explore them.

It is advisable to continue the shafts to a greater depth, gathering in the quartz feeders from the north, and the epidote vein under the foot wall, when we may reasonably expect the occurrence of copper in quantity and in masses.

It is intended to commence an adit level from the foot of the bluff near the south line of the location, and drive across the ground at right angles with the course of the veins traversing the range. This work will serve to prove the ground more fully than any other mode, by intersecting below the surface

any intermediate vein, and where its character can be better determined than from the surface appearance; and should the vein on which we are now mining be permanently worked, as we expect, the adit will be of the greatest utility in draining the water, and serving for a road to draw out the rock and copper.

We have now at work four miners in shaft No. 2, and four in shaft No. 3, and eight men to fill and land buckets to the windlass and drive the hoisting team; one blacksmith, a cook, carpenter, teamster on the road, and mining captain; to which force we shall soon add two other miners to work at the adit, making in all twenty-two men and the cook (female).

Having to pack on horseback the principal amount of supplies to provision the mine, the present force is as large as can well be worked during the summer and fall. In the winter the sleighing enables us to draw over our roads the supplies at a comparatively cheap rate: and the mine should be stocked in the winter for a year's consumption, for the number of men intended to be employed.

We are now making a survey of the line of the adit, and a diagram of the work will be sent with my next letter.

Yours very truly,
ALGERNON MERRYWEATHER, *Agent.*

TREASURER'S REPORT.

Receipts.

Paid in as per articles.	$1 00
Sales of 3,000 shares of stock,	
112 " " used instead of cash for Company purposes,	
2,888 shares at 2½,	$7,220 00
Bills payable,	1,500 00
Loans (being for assessments paid in advance to assist the Company),	4,075 00
Loans from John Sly, on interest,	2,000 00
Insurance collected,	47.75
	$14,843 75

Disbursements.

Expenses in New York,	$161 90
Amount paid in as per vouchers (agents' drafts),	11,948 95
Interest,	68 56
	$12,179 41
Balance in Treasury,	2,664 34

Resources.

Balance in Treasurer's hand,	$2,664 34
Cash at Mine,	117 00
Assessment called 15th June,	10,000 00
	$12,791 34
Amount of Expenditures as per Agents' Report,	14,981 35
Less paid drafts,	11,948 95
	$3,032 40
Loans due,	6,075 00
Bills payable,	1,500 00
	$10,607 04

Leaving available resources over indebtedness, $2,183 94.

Besides this the Company have several thousand dollars' value in buildings, horses, oxen, mining tools, stores, and crops, &c., &c., which it was not thought necessary to inventory the present year.

The financial accounts now submitted show that the assessment of 15th of June was nearly all anticipated by loans, &c.; and in order that the work can be pushed with proper energy, it will be necessary to call in another assessment of 50 cents per share, payable in September, which will amply suffice for the year. In the present state of the work, true economy makes it the duty of your Directors to speed the work as much as possible, and also

calls upon the Stockholders for a prompt payment of the assessments, so that the operations may not be impeded by want of funds. It is but justice to say that the assessment of 15th June has been promptly responded to.

Much will be done during the winter to develope the mine. Every thing at the present time looks promising, and although your Directors are fully aware of the uncertainty of the early stages of mining operations, they cannot but feel much encouragement in the prosecution of this work.

By order of the Directors,

JAMES T. WATERS, *Secretary.*

JOURNAL OF SILVER AND LEAD MINING OPERATIONS.

THE SILVER MINES OF CALIFORNIA.

The fame of the silver mines of California is quite as ancient as the knowledge of its gold placers, and it is the opinion of gentlemen well informed in the matter, that ere many years shall elapse, we shall see the business of silver mining take high rank among the mining interests of the State. So far as discoveries have been already made, the presence of silver seems to be chiefly confined to the Central and Southern portions of the State, and there can be little doubt but that when the mountains of that portion of the State are thoroughly explored, silver ore will be found as abundant, and perhaps as rich as in the most favored regions of Mexico or Peru.

We gave some two or three weeks since, from the "Monterey Sentinel," an article with regard to the silver mines of Monterey county, from which it appears that there are not less than six distinct views of silver on one ranch in that county, and it is also stated by those who are well acquainted with the silver mining districts of Mexico and Peru, that a remarkably close resemblance exists between those regions and the Sierras of Monterey.

Rich placers of both gold and silver, were known to exist in Monterey county more than fifty years ago, and were worked to some extent, though in a very loose and unskilful manner. The priests of those days invariably discouraged the search and working for minerals, as a matter of policy to themselves; hence the loss of the particular knowledge with regard to their location and extent. Sufficient however is known to warrant the conclusion that the mines were both extensive and valuable. Silver ore in Monterey county was so plenty and so easily obtained about the close of the last century, that it was frequently used for making bullets—the mineral being a mixture of lead and silver, the silver forming about twelve per cent. of the mass. The most reliable evidence also exists with regard to silver mines on or near King's river, near the head of the Tulare valley. Other veins are known to have been worked to some extent in Santa Barbara county. It is also known that there are valuable veins of silver ore in Calaveras and Tuolumne counties.

One of the veins in Monterey county on the Alizal ranch, the one from which it is supposed the early Californians obtained the material for making their bullets, is said to have been re-discovered and worked for a short time by a Mexican in 1831, who finally abandoned it on account of a dispute about the proprietorship. From that time it remained undisturbed until 1852, when a party of German miners, who had but little experience and less capital, again took it in hand, but for these two very sufficient reasons soon gave it up again. They wrought it sufficiently, however, to prove that it would be valuable, under proper management, with a sufficient capital. Two more veins have since been discovered in the same immediate neighborhood, which present every indication of being extensive and valuable.

From the facts which appear to be authentic, and the accuracy of which might be thoroughly tested by inquiries and examinations, in the neighborhood alluded to, there would seem to be very little doubt of the truth of the assertion put forth in the commencement of this article, that the business of silver mining must become a very important branch of California industry. In order to bring about this result, it is desirable that the first operations should be undertaken by experienced managers. A mine of either gold or silver, which might be made extraordinarily productive under an experienced and liberal management, may, under the control of inxperienced managers, although with an abundance of capital, fail to yield even a paying return. It is therefore to be hoped that the first experiments in silver mining in California, will not, as has been too frequently the case in gold mining, be intrusted to incompetent hands. It is desirable that the attention of enterprising capitalists and practical miners may be turned toward this promising interest. The occupation of silver mining has ever been in all countries, more productive and certain than that of gold. There is at this time a great demand for silver, both as a circulating medium and for the arts; and it will be most fortunate for California if she should find it in her power to supply this deficiency. With gold and quicksilver in abundance, and inexhaustible supplies of all the grosser minerals, we need now but an equal development of the argentiferous ores to make us, as a nation, independent of the world, in every thing which relates to money and commerce.

With this end in view, we shall endeavor to collect and lay before our readers, from time to time, such facts as we may be able to obtain with regard to the discovery and the proper methods of working silver mines. We shall close this article, the length of which, nothing but its importance will justify, with the following paper, by Guido Kustel, translated for the San Francisco Chronicle from the "German Journal" of that city:

"Silver mining will become a much more important interest in the future f California than at present, because it is beyond doubt that the mountains, particularly in the southern part of the State, contain many silver mines. owever, the discovery and digging of silver ores are more difficult than those of gold. Silver is less widely diffused, and in many of its forms is not easily to be recognized. Gold is easily discovered, on account of its dissemi nation in gold districts, and of its striking appearance, unless in combination with Tellurium or Molybdenum. The pan soon tells the gold miner what he can expect. A gold vein is almost the same to him as a quarry vein. When he seeks the one, he seeks the other. When he finds the quarry he can easily know whether it contains gold. But it is different with silver. It is true that in a small plain in Peru pure silver was found just below the surface of the soil, and was found clinging to the grass roots on the sod, but that was really a silver placer. Pure silver has likewise been found in thin leaves, in connection with some ores of iron; but generally its natural state is in an ore. He who would seek for silver ore, should examine the geological formations of stone, which will often furnish information of what is to be expected. The extraction of silver from the ore requires an exact knowledge of the nature of the metal and of the substances in connection with which it is found in the ore, before the miner can decide upon the best method of handling his material.

Nearly every silver mine yields, besides the ore, a mineral which is too poor to be directly worked up, and yet too rich to be thrown away. A good method of working is almost indispensable. In some quartz mines of Mariposa county, a glittering red ore, rich in a clayish silver, appears with the gold, but for the want of a good working process, it is left to the wild flood.

The melting, however, is applicable to silver ore only under peculiar circumstances. Amalgamation is more usual and cheaper, but it is tiresome, and the ore must, in most cases, be previously roasted with comman salt to prepare it for amalgamation.

The new methods of obtaining silver from copper ores are of much impor-

tance, because they are much cheaper than amalgamation. One is called Augustin's method .Where there is chloride of silver he casts it into a strong solution of common salt, and the solution dissolves the silver, which is then precipitated with copper. For this purpose a peculiar form of copper (cement kupfer,) which is obtained by precipitating it from a natural solution of sulphate of copper with the aid of iron, is used. The other method is Ziervogel's, and is grounded on the fact that oxide of silver is unaltered by a certain degree of high temperature, which changes sulphate of copper and iron to oxides. By wasting oxides of silver with the sulphate of copper or iron, the sulphuric acid leaves the baser metal and joins the silver. The sulphate of silver is then dissolved in water and precipitated with copper. By this method only from five to eight per cent. of silver is lost, and it is undoubtedly the best method in use. The specific gravity of silver is 10.50. It is found in a state of nature pure, in combination with sulphur alone, with sulphur and other metals, with chlorine alone, with iron, with antimony, with arsenic and antimony, and seldom with iodine, bromide, or quicksilver.

Silver ores are found almost exclusively in veins in gneiss, mica, graywacke, and clay slate, and sometimes in greenstone, transition limestone and the latter limestones. The veins are principally of quartz, hornstone, lime and brounspar, barytes and fluorspar.

WASTE OF SILVER IN ROASTING ORES.

SIR—The observation in your last Journal, giving the result of elaborate and well-digested experiments of Prof. Plattner, on the roasting of silver ore, *per se*, together with amount of loss of silver in the treatment of various grades of ore, when mineralized by various substances, demands the most serious attention of all parties interested in the treatment of silver ores; or those who may be interested in silver mines. Prof. Plattner, as you are aware, is a gentleman of world-wide reputation in metallurgical pursuits; and any observations emanating from his great and varied experience are worthy of our highest consideration, and the more especially as we now import such a quantity of dry silver ores from South America, and other countries, as well as many of our leading capitalists being interested in silver mines abroad, at which the ores are, in some instances, treated either by means of amalgamation or smelting; in either case roasting the ore is a necessary operation. I am advised that Prof. Plattner will continue these experiments, in order to arrive at a sound practical conclusion thereon, which is much to be desired.

Many years since I had the benefit of Prof. Plattner's personal instruction; since which I have been extensively engaged in the treatment of silver ores, both at home and abroad, by smelting and amalgamation, I believe of all the known classes of silver ores. And being subject in such treatment to the losses described so clearly by Prof. Plattner, I will with your permission, sir, shortly allude to some treatment of ores which I adopted in order to lessen such loss; and I must here regret that I have mislaid some tabular formula which I adopted, and found to answer to a considerable extent in treating ores of different percentages of silver, mineralized by different substances, or alloyed by various other minerals. It was a table I had prepared for my own use, as I was largely interested in the purchase of silver ores at that time; the loss of this table, or form of treatment of ores, as well as indisposition, prevents me at present from going as fully into the matter as I could desire, in order to be understood; and I must remark, that to treat ores properly, a careful and complete chemical analysis must be made. Now this is too little understood, and too little practised, to expect that every person engaged in the treatment of silver ores can by any possibility know how to treat the ore placed in their charge for reduction, so that you see primarily our ignorance must produce great loss; and secondly, the difficulty of reconciling the prac-

tical treatment with the chemical analysis, needing every attention, care, and closely observed practice. Why, sir, your Journal has teemed with remarks on the treatment of gold quartz, while the subject of silver ore treatment is far more worthy the attention of the scientific man, as involving close research. Gold results in mechanical treatment, silver into that of chemical manipulation, and in its combinations with nearly all the common metals and minerals, in a variety of forms and states of mineralization.

The silver ore imported into this country is large in amount of tonnage at present, and is on the increase, yielding in some cases not more than 30 ozs. per ton, and running up from that ley to several thousands of ounces per ton. These ores may be said to be competed for by two or three houses only; there are a number of bidders, but their offers are so short of the real value, that they excite a smile from the more knowing ones, who generally purchase to advantage. I have known the offers to vary as much as 95 per cent. per ton of ore, and they excuse themselves in making these offers on the ground as shown in Prof. Plattner's experiments—viz., loss in treatment; that they are never able to obtain any approach to the assay product in treating the bulk, and that they offer accordingly to keep themselves safe, or, in other words, to perpetuate their own ignorance.

The silver ores imported are treated by amalgamation, or by smelting. Their amalgamation is conducted after the usual process, by mixing common salt in quantities (generally having a reference to the percentage of silver contained in the ores); a mixture is thereby effected which, on being roasted, the silver in the ores undergoes a chemical change, which converts it into chloride of silver from its previous state of mineralization. It is then requisite, either in barrels, or by other means, to bring it into intimate contact with mercury. The quantity necessary of quicksilver also depends on the percentage of richness for silver, which is taken up by chemical affinity in the form of amalgam, aided by using scraps of iron, and, in some cases, a little lime. Now, in this process, roasting the ore is the great hinge on which the success of the treatment depends; hence the importance of Prof. Plattner's experiments. The other process is that of smelting, but the silver ores are generally roasted *per se*, and afterwards mixed in varied proportions with ordinary lead ores, which both act as a flux and take up the silver, which is subsequently obtained by desilverizing the lead in the ordinary way, the roasting loss occurring as a matter of course, alluded to by Prof. Plattner.

Now, sir, in my practice in amalgamation of silver ores, I obtained the best results from using 12 per cent. of salt for ores containing 100 ozs. of silver per ton, increasing or diminishing that quantity as the richness or otherwise of the ore for silver warranted, using about 650 lbs. of mercury per ton of ore, as I always found an excess of these menstrums to be attended with benefits in practice over and beyond the chemical formulary of theory, adding some scrap iron and a little lime for some classes of ore.

In the roasting of silver ores for smelting I always used a little salt, the quantity entirely depending on the character and extent of the mineralization. Now in theory, the salt would be found to form a chloride of silver; in practice it does no such thing—that is, if you do not exceed a certain limit, which is to be ascertained by an analysis of the ore treated as to the quantity of sulphur, arsenic, or other matter it contains; and by the use of salt in roasting I found a very manifest benefit of results.

I fear that I have trespassed too much on your valuable space with my crude remarks, but must hope some others more competent will give us their views on a subject of great interest to the trade of this country. My bodily indisposition prevents me from giving all the details I could wish in this communication, but I would like to see our School of Miners imitating Prof. Plattner.—*London Jour.*

/25-

MINING MAGAZINE.

EDITED BY

WILLIAM J. TENNEY.

CONTENTS OF NO. III., VOL. VII.

ARTICLES.

JOURNAL OF MINING LAWS AND REGULATIONS.

COALS AND COLLIERIES.

IRON AND ZINC.

JOURNAL OF GOLD MINING OPERATIONS

126

Contents.

THE

MINING MAGAZINE:

DEVOTED TO

Mines, Mining Operations, Metallurgy, &c., &c.

VOL. VII.—SEPTEMBER, 1856.—No. III.

ART. I.—THE IRON MANUFACTURE OF GREAT BRITAIN—THEORETICALLY AND PRACTICALLY CONSIDERED. BY WM. TRURAN, C. E. No. 8.

(Continued from page 58, vol. 7.)

SECTION VII.—THE BLAST, OR COMPRESSED ATMOSPHERIC AIR EMPLOYED IN SMELTING.

DENSITY OF THE BLAST.

THE pressure or density of the blast is a matter of considerable importance in smelting. It is regulated by the height of the furnace; size of the hearth; and qualities of the fuel. In the infancy of the manufacture, owing to the low state of mechanical science, the blowing machines employed were very deficient in the power necessary for compressing the air. The blast obtained was inferior in quantity and of a low pressure; but the furnaces were of small capacity, and the produce of iron was on the same limited scale. With the improvements in the manufacture of machinery, attention was directed to the blowing machinery of iron works; greater volumes of blast, compressed to a higher density, were obtained; and with additional blowing power, the capacity and height of the furnace was increased, and the produce of metal augmented in a similar ratio.

The density of the blast is dependent on the height of the furnace, inasmuch that the greater or lesser weight of the column of solid materials affects the density of the stratum of fuel under combustion. But the blast furnaces of the present day are built nearly of one uniform height;—a deviation of more than 5 feet from the average height is rare. The variation, then, in the pressure exerted by the superincumbent materials on the fuel, from the greater or lesser height of the column in different furnaces, is not great, and may safely be omitted. Therefore, in proportioning the density and volume of the blast, we must consider the internal dimensions of the furnace, and the qualities of the fuel, as the governing agents.

In the present state of the manufacture, 2 lbs. to the square

inch is a minimum degree of compression. A few years since, the experiment of a lower blast was tried at the Wingerworth furnaces, but after great expense and waste of material, it was finally abandoned, and a blast of 2¼ to 2½ lbs. to the square inch substituted. And more recently we have witnessed numerous instances of the injurious effects produced by a weak scattered blast on the make and quality of the crude iron.

The maximum density of blast is dependent, to a certain extent, on the fuel. If the coal is of a hard compact structure, containing a large percentage of carbon, a pressure of 4 to 5 lbs. to the inch may advantageously be adopted. With a weak, friable coal, containing a low percentage of carbon, 2 to 2½ lbs. is very commonly used. The dense cokes of a highly bituminous coal support a blast of 2½ to 3½ lbs.

As a general rule, from which we have seen no exceptions, the density of blast applicable to any given coal—the other conditions being equal—is proportionable to the density of the coke produced from such coal. Hence, the hardest and heaviest coke will carry the strongest blast, and *vice versa.*

Generally speaking, the increase in the density of the blast has not kept pace with the enlargements of the blast furnace, and yet they are directly dependent on each other. The density must be such, that the requisite quantity of atmospheric air penetrates to the opposite side of the hearth, in order to maintain active combustion in the fuel descending farthest from the tuyere. The wider the hearth the more numerous will be the obstructions to its passage across. Any increase, then, in the width of the hearth should be met by a corresponding increase in the density of the blast. The degree of compression is undoubtedly carried farther now than formerly, but it is not sufficient for the large hearths constructed.

In the old blast furnaces the width of the hearth seldom exceeded 3 feet; through a mass of materials of this thickness only had the blast to penetrate. For this purpose the density usually was 1½ to 2 lbs. If the obstruction offered by the thickness of material required a blast of this density for the perfect combustion of the fuel, it is very evident that with a wider hearth a proportionately higher density is required. If to penetrate 3 feet required a mean pressure of 1¾ lbs. to penetrate twice the distance requires twice the pressure, or 3½ lbs. to the square inch. Considering the pressure of 1¾ lbs. as suitable for the 8 feet hearth, an approximation may be made to the pressure required for any other width. The 1¾ lbs. to 3 feet, is equal to six tenths of a pound nearly for each foot. Hearths are now constructed up to 8 feet in breadth: for such, the pressure of blast should, by this rule, be 4¾ lbs. to the inch. For the more common breadth of 6 feet the pressure will be 8½ lbs; but in practice a lower density is used. Partly from not justly considering the relation

which the density of the blast should bear to the breadth of the hearth, and partly from the blowing engines having been constructed to deliver blast of a fixed density, an increase, if desired, is not attainable. Furnaces having the widest hearths are blown with engines which maintain a pressure of 2½ to 3 lbs. to the inch: but the diameter of the discharging pipes are such that, at their termination the pressure is commonly under 2 lbs.

Complete combustion of the fuel with this low pressure is not to be expected: the portions farthest from the tuyere do not receive the requisite volume of oxygen gas for creating a high temperature; consequently, the carbon of such fuel does not contribute by its combustion a maximum quantity of caloric for the reduction of the ore and flux. The entire calorific powers of the fuel are not developed and brought to bear on the fusion of the ore; hence, the quality of the resulting crude iron is deteriorated.

The distinction between volume and density is not sufficiently attended to by practical smelters. With the enlarged capacity of the blast furnace, an increased volume of blast has been employed; but the mere increase of volume is not sufficient to obtain the entire benefits accruing from the employment of large furnaces. Augmenting the volume alone, implies the ability of a blast of given density to penetrate the mass of materials, whatever may be the breadth of the hearth,—a manifest error. From inattention to this circumstance the capacity of the blast furnace has been increased from about 80 to 260 and 280 yards, with an equally great, if not greater increase in the volume of the blast; but the density remains nearly the same. Had the density of the blast been augmented in the same ratio as the increased dimensions of the furnace, the produce of the largest blast furnaces would be more in unison with their capacity.

But while we advocate the employment of a blast of adequate volume and density, we freely admit that no form of tuyere yet invented can produce a perfect combustion of the carbon. The blast of low density supplies the nearest coal, but fails to penetrate the materials to the farthest: a high density, while it supplies ample air to the farthest, affords scarcely any to the nearest coal. A tuyere which shall afford to each the requisite quantity of air for perfect combustion is much wanted, and until it is provided a high economy of fuel will not be attained.

We are of opinion that a compound tuyere, consisting of a central discharge of very dense blast, and an exterior annular discharge of a less dense blast, eventually will supersede the present single tuyere.

The necessity for compressing the blast to a less or greater density is generally admitted by iron smelters; for under no other circumstances can sufficient air be brought in contact with the fuel: occasionally, however, the patent records of this country contain ingenious substitutes for the common plan of forcing a draught.

Recently a furnace was built in the neighborhood of Caerphilly, in which the requisite draught was attempted to be maintained by exhaustion, but without success, and the operations were discontinued. A different result could scarcely be anticipated; for if a brief consideration is given to the rapid rate of combustion necessary to the maintenance of the high temperature of a blast furnace, the impossibility of supplying the atmospheric air by an indraught becomes manifest.

MODE OF APPLYING THE BLAST.

A diversity of opinion exists as to the best mode of applying the blast. The usual plan is by three tuyeres, one on each side and the third at the back; but departures from this mode are to be seen at several works.

It is seldom that a fewer number are employed with modern furnaces, but a greater number is considered by some smelters as being more advantageous, and furnaces may be seen receiving blast through 10 and even 12 pipes.

The volume of blast is fixed; therefore, when more than 3 pipes are used, and the original density of the blast is desired to be maintained, their diameter is reduced, so that the total sectional area remains unaltered. The blast, then, being delivered through a larger number, the discharge by each pipe will be reduced in the same ratio as its reduced sectional area.

The advantages which are supposed to attend the employment of a large number of small pipes, are, a more perfect combustion of the fuel, and, consequent thereon, a greater economy of blast and smelting materials, and an increased produce. It is maintained by some smelters, that such advantages have been realized whenever the number of tuyeres has been increased. Certain it is, however, that more than one has obtained letters patent for the supposed discovery of such improved (?) mode of bringing the blast in contact with the fuel, and the employment of four or more tuyeres is now common in several districts.

We cannot subscribe to the general approval of numerous tuyeres. After a lengthy trial at several furnaces, we were unable to discern any superiority over the fewer number. And if due consideration be paid to the circumstances which determine the volume and density of the blast, any other result is not to be expected. The admission of the blast at several points in the circumference of the hearth, doubtless conduces to a more perfect combustion of so much of the fuel as is within the range of the blast, but it is detrimental to the combustion of the remotest portions. For the profitable consumption of the fuel, each and every piece within the zone of fusion requires to be supplied with the necessary volume of atmospheric air. This can only be accomplished by having a blast proportioned in

volume and density to the size of the hearth, and quantity of fuel consumed in a given time. This last, premising that the fusibility of the ore and capacity of the furnace be known, may be easily ascertained. If then the volume be proportioned to the breadth of the hearth and quantity of carbon, and the density of the blast is fixed, the comparative efficiency of a less or greater number of tuyeres may be measured by the quantities of blast decomposed by the fuel near the leyel of the tuyeres.

If the blast is cut up into a number of small jets, the ability to penetrate the materials is inferior to that of larger jets, and effects very similar to those with a soft voluminous blast are produced. A high local heat is maintained, conjointly, with a defective combustion in the remotest portions of the hearth. The deficiency of oxygen to a portion of the fuel deprives the ore of the reducing power of so much carbon; and entails on the manufacturer the necessity of using a larger quantity to the ton of crude iron.

The deficient intensity of the small jets to penetrate to the remotest parts of the hearth, is partly understood by the advocates of numerous small tuyeres; and to remedy the deficiency, a high density of blast, amounting in some instances to 6 lbs. to the square inch, is employed. At the works in the Swansea Valley, the Aberdare, Abernant, and other works in Wales, a high pillar of blast is used with furnaces under the average height, and having comparatively narrow hearths.

The effects produced on the Dowlais furnaces by increasing the number of tuyeres were very remarkable. In the Swansea Valley the furnaces are generally blown with 10 tuyeres, 3 each side and in the back, and 1 in the breast of the fall; at the Dowlais furnace 6 tuyeres were substituted for 3, 2 on each side and back instead of 1, and no alteration was made in the volume or density of the blast. Whatever alterations then which occurred in the working of the furnaces resulted from the increased number of tuyeres. In 1847–'48, during a period of 15 months blowing with the double set of tuyeres at each furnace, the average yield of coal for smelting was 50.1 cwts. The average yield with single tuyeres during the two years preceding the experiment was 45.3 cwts. With the single tuyere in each house, the average weekly make of each furnace was 101 tons; but with the double tuyeres it was 98. A loss therefore occurred from using the small tuyeres of 4.8 cwts. of coal on each ton of crude iron produced, and a diminution of 3 tons on the weekly make. Estimated on the produce of pig iron at that establishment during the above period, the additional consumption of furnace coal consequent on the altered system of blowing amounted to 27,600 tons. If to the value of this coal there be added the expenses incidental to the alteration, the increased consumption of iron-yielding materials, and the deficiency in make, the

policy of using, under any circumstances, a number of small tuyeres, may fairly be questioned.

The working expenses of the small tuyere system are greatly in excess of the large tuyere. Two or three times the number of pipes, tuyeres, and joints have to be kept in repair. The leakage of blast is increased in the same ratio, and owing to the excessive supply of air to the fuel near the tuyeres, the heat generated at each cluster is so intense, that recourse is had to water breasts around, and hollow metal blocks below the tuyeres. The water circulating through these keeps the tuyeres comparatively cool, by absorbing a portion of the caloric destined for the reduction of the ore.

In Scotland it is a rare circumstance for a furnace to be blown with so few as 3 tuyeres. At the Langloan works they are blown with 4 tuyeres, two on each side; at the Dandyvan furnaces, 5 are used; at the Gartsherrie, 4, 5, and 6; at the Monkland, 5; and at the Goran furnaces, 8 tuyeres—8 on each side and 2 in the back. All of these furnaces have large hearths. The consumption of fuel to the quantity of blast delivered is excessive, as we have elsewhere shown. May not a portion of this excess be accounted for in the use of numerous small tuyeres? We have seen that the employment of 6 small instead of 3 large, resulted in an increased consumption of fuel of nearly 5 cwts. per ton of iron. We do not know of any circumstance connected with the Scotch furnaces which exempts them from using a greater quantity of coal than is necessary under like circumstances.

The plan of delivering the blast through numerous small tuyeres is in use at several English works. A number of the Yorkshire furnaces are blown with 6 tuyeres. We are not aware, however, of a single instance wherein the adoption of the plan has been followed by a superior economy of fuel, blast, or other material, or any other advantage commensurate with its greater first cost and maintenance.

NOZZLE-PIPES AND TUYERES.

The beneficial effects which result from employing a blast of the requisite volume and density, may be, and often are, destroyed by using improper pipes for the delivery into the furnace. The longitudinal section of the nozzle-pipe and tuyere exercises a very important bearing on the efficiency of the blast. Unless these are justly proportioned at first, and afterwards maintained to their original section, it is impossible that the blast delivered can produce a maximum effect.

The common error committed in nozzle pipes is the making their horizontal section to converge too rapidly. The difference in the diameters is too much for the length of the pipe. With

pipes having much taper the distance to which the blast is projected is materially diminished; at a very short distance from the outlet the density is very little superior to that of the atmosphere. The tapering form of the pipe favors the divergence of the blast, whereas in smelting, a dense concentrated blast is required at several feet from the point; for under no other conditions can the blast penetrate a mass of materials to supply air for the combustion of the entire quantity of fuel.

The effects produced on the furnace from using pipes of too much taper usually present themselves in an increased consumption of coal, and the burning of the brickwork around the tuyere. The increase in the coal is often very considerable. And in consequence of the reduction in the density of the blast immediately after its emission from the pipe, it is unable to penetrate far into the materials; the quantity of air to the fuel in the vicinity of the tuyere, therefore, is so great, that an unnecessarily high temperature is created, to the injury of the brickwork of the hearth.

The diameters of the pipe, its length and thickness, should be determined, after mature consideration, by a responsible agent, instead of being left, as at present, to the attendant workmen, and careful supervision should be exercised in the smithy. The pipe conveying the blast into the nozzle-pipe is usually a fixture, in respect to distance from the furnace; and in the event of alterations in the position of the tuyere, a different length of nozzle is required. If the distance is shortened, the two diameters of the pipe remaining unaltered, the taper and divergence of the blast are increased; but if lengthened, the taper is reduced and the blast more concentrated. Short pipes are sometimes employed to connect the large end of the nozzle to the blast pipe; but since their employment increases the number of joints for leakage, and creates obstructions to the free delivery of the blast, they should be avoided whenever practicable. A more ready mode of shortening or lengthening the distance between the tuyere and fixed pipe is by a telescopic pipe, fitted with a ring piston, which works air-tight in a cylinder, as delineated in the plate of details. Pipes of this description have been several years in use at the Dowlais furnaces; for facility of working and economy of blast they are unequalled. Their first cost is greater than the usual fixed pipe, but the numerous advantages which they possess amply compensate for the greater outlay.

The width of the hearth should have due weight in determining the taper of the nozzle. If it is wide, the taper should be reduced. The old hearths were about 3 feet across; from this circumstance, the section formerly was of little importance. But a pipe which answers well for a hearth of 3 feet, supplying atmospheric air to all the fuel therein, would be totally inapplicable to one of 6 feet. The diameter of the point is usually

determined by the quantity of atmospheric air intended to be delivered; and from numerous observations we are of opinion that, for medium size hearths, the large end should be one fourth larger for each foot in length, and for other lengths in proportion. By this rule the outer end of a 4 inch pipe 18 inches long will be 5½ inches. If the metal in the end of the connecting pipe is very thick, a short enlargement should be made to the nozzle to go over it, that the interior of the connection may present an unbroken surface.

The condition of the point of the nozzle should occasionally be examined, that any upsetting or burning of the metal may be remedied. For want of such examination and repair, the point is battered up, and the intensity of the escaping blast broken. At some furnaces very thin pipes are used, but from the weakness of the thin metal when heated they maintain their original form for a very short period. Pipes made from ⅜ or ¼ inch boiler-plate iron are preferable in every respect, and a less thickness should not be employed. Their interior should be quite circular; the ends filed up cold to bring out the angle of the metal quite sharp, and the point filed up to a gauge, or bored to the exact dimensions desired, taking care, however, that the thickness is not materially reduced by the filing.

In numerous iron works, from a mistaken idea of economy, rudely constructed pipes are used, presenting in their transverse section, some resemblance to a circle, but differing in form at different parts of the length. As the use of such pipes is attended with a certain waste of blast, it is not difficult to see that any saving effected in their manufacture is more than balanced by the imperfect manner in which the blast is delivered. From our own experience we can say, that the additional expense incurred in making a superior pipe is amply compensated by the greater efficiency of the blast.

The interior of the water tuyere is usually made as represented in the plate of details. About two fifths of its length inside, measuring from the inner end, is made parallel; from this place to the outer end the bore is enlarged to about 1¼ times the diameter of the inner end. The smallest bore is made of nearly the same size as that of the nozzle. The space around the nozzle pipe, inside the large end of the tuyere, is generally rammed tight with fire-clay or other packing to prevent the escape of blast.

The diameter of the water pipe is from ⅝ to 1 inch, according to circumstances. The thickness of the cast metal around the bore of the tuyere at the inner end is just sufficient to encircle the water pipe, and protect it from the direct action of the heat, diminishing at the outer end to about 1 inch. In turning the water pipe to the spiral form, great care should be taken to avoid flattening or opening at the weld. From want of attention in

the turning many tuyeres are rendered useless, and by the escape of water much injury has been occasioned to the furnace.

The connection of the inlet pipe cast in the tuyere to the fixed water pipe should be such as will admit of a ready separation and reconnection when changing tuyeres. This is best accomplished by having one or two universal joints, by which the direction of the pipe may be suited to the position of the tuyere, and a pair of small flanches, with screw pins for disconnecting.

To maintain the requisite coolness at the point, the water should circulate at the rate of 10 to 12 gallons per minute for each square inch of sectional area of pipe. The height of the reservoir above the tuyere, should, wherever practicable, be equal to the height of the furnace.

As a knowledge of the quantities of blast discharged by tuyeres is of considerable importance in the management of works, we annex a table of the maximum discharge through an orifice of one inch area at various pressures. The calculations are founded on the rule: To find the velocity with which air rushes into a medium rarer than itself, let V. represent the velocity with which it rushes into a vacuum (1889 feet per second); D the natural density of the air, and d the density of the air contained in the vessel into which it is supposed to run; then

$$\text{Velocity} = V\sqrt{\frac{D - d}{D}}$$

TABLE OF THE DISCHARGE OF BLAST AND ATMOSPHERIC AIR AT VARIOUS DISTANCES.

Pressure in lbs. per square inch.	Velocity of the issuing blast in feet per second.	Cubic feet of blast discharge per min. per inch area of orifice.	Cubic ft. of atmospheric air discharged pr min. per inch area of orifice.
1	385	139	148
1½	402	168	185
2	455	190	208
2½	509	212	247
3	549	228	273
3½	585	244	301
4	616	257	325
4½	643	267	347
5	670	279	372
5½	692	288	394
6	714	298	417

In practice we find that the average discharge through tuyeres is from one eighth to one tenth less than these quantities.

COMPOSITION OF ATMOSPHERIC AIR, BY WEIGHT.

Decimally atmospheric air consists of

Oxygen,	2100
Nitrogen,	7750
Aqueous vapor,	0142
Carbonic acid,	0008

and weighs 527 grains per cubic foot; hence, 29,760 cubic feet weigh one ton.

Section VIII.—Form of the Interior of the Blast Furnace.

The form of the interior has an important bearing on the duration, economy of materials, and smelting power of the blast furnace. The nature of the fuel and ores to be smelted, and the quantity of crude iron desired in a given period, regulate the principal dimensions; but in many districts they are determined by local usage, without reference to their propriety or fitness.

Of late years some attention has been given to the form of furnace calculated to yield a maximum quantity of metal with a minimum consumption of materials; and considerable departures from the old section of furnace have been made. Looking, however, to the great improvements which have been effected in the manufacture of iron generally, we are of opinion that improvements in the blast furnace have not kept pace with those in the other departments. Much of this doubtless is owing to the little attention paid to the subject by smelters; but much also is due to the serious consequences which would be entailed on the manufacturer in the event of failure of any experiment. In most of the other departments, the cost of making the necessary alterations for testing the value of any supposed improvement is comparatively trifling, to the expense which must be incurred in experiments on the construction of blast furnaces. And if unsuccessful, the change back to the former arrangements may be made in a few days; but in the case of the blast furnace, any alteration of the interior construction involves the blowing out, and is attended with a delay of some weeks or months in the operations. With such extreme risk, then, of loss, the manufacturer is not so much to be blamed for building his furnaces of the present form.

Great as the improvements in the manufacture of iron in the present century have been, any very striking improvement over former methods generally has been the result of several years cautious experimenting. The difference between the present blast furnaces and the furnaces of sixty years since, though confined principally to dimensions, is the result of numerous experiments. On comparing the lines of furnaces recently built with those of the furnaces erected in the former period, we find the difference to consist chiefly in the enlarged diameter of the boshes. The increase in size, though considerable on the whole, has been attained by successive enlargements; the increase at any one time has been small, from the constant fear of failure if a great and sudden departure were made from the established proportions. In other respects the majority of the furnaces of the present day are very little superior to those of a former period; and by their design, it is evident that the laws of combustion and draught are not understood by the great body of practical smelters.

Among ironmasters the form of the hearth appears to be a mere matter of opinion. Leaving the size for future consideration, it is desirable to ascertain the form which conduces to the best results. In Staffordshire square hearths are common; a few are constructed in Scotland; the same form prevails largely in South Wales. At the Plymouth and Aberamman works near Merthyr Tydfil, square hearths are used; they are common also in the anthracite furnaces of the Swansea Valley; and the furnaces on the eastern side of the basin. A slight variation from the square form is seen in hearths having their angles rounded off, as in the Langloan furnaces; or their sharpness diminished, as in the Ystalyfera. In Scotland hearths of a circular form in the plan are general, and they are used in some modern Staffordshire furnaces. At the Rhymney, Tredegar, Sirhowy, Ebbw Vale, Cyfarthfa, and other works, this form is generally adopted; probably one half of the Welch furnaces are provided with hearths of this form in the plan. In some of the Scotch works the plan partakes of a pear shape,—the back circular, and diminishing in breadth from the side tuyeres to the damplate, either by a straight or curved wall.

Each form of hearth has its advantages. The square is especially applicable where more than one tuyere is blown at a side, as in the anthracite furnaces; but the combustion of the fuel is not generally so well accomplished. The portion which descends in the angles is out of the direct influence of the blast, consequently, yields an inferior heat. In facility also for working, this form is inferior to others. The angular space between the cinder fall and tuyeres is beyond the direct action of the blast, and cannot be approached by any instrument from the fall. Collections of cinder and partially fused matter lodge in these recesses and reduce the available area of the hearth. Indeed, after being in blast for a short period, all the angular spaces in the square hearth are filled up by the adhesion of vitrified matter to the brickwork, and the plan of the working portion is thus brought to a circular form.

The circular hearths approach more nearly to the form produced by the fusion and flow of the materials, but is defective in the sharp angles at the cinder fall. A portion of the hearth is from these angles rendered inaccessible to the workmen from the front; hence, the removal of any material which may lodge there is attended with difficulty. A modification of the circular hearth, having a portion of the circumference opposite each tuyere, flattened for a space of 18 to 30 inches, is adopted at some works. It places the tuyeres a few inches nearer to each other than the diameter of the circle; but we are not aware of any advantage from this alteration which would not be better answered by a perfectly circular hearth of a diameter equal to the diminished width.

The plan used at some Scotch works, and altogether so at the Dowlais and Hirwain furnaces, fulfils the conditions required in a hearth, more so than any other form that we have seen. By avoiding sharp angles in the plan the entire bottom is accessible to the workmen, and the risk of semi-vitrified matter lodging in, or adhering to any part of the hearth much diminished. We have observed in furnaces which have been blown out after being in blast a very short period, that the working part of the hearth has taken this form, whatever might have been its original shape. This seems to point to its adoption at first, instead of leaving the metal to round the angles and fill up the hollows. Certain it is that when the square or circular form is adopted, the fluid metal acting on the material of the hearth, widens the fall at the junction, and render necessary frequent repairs. It has a similar effect on the sides of the pear-shaped hearth, but from the absence of angles, the necessary repairs can be made with great facility.

The width of the hearth from tuyere to tuyere is regulated by the dimensions and quality of the fuel, and the diameter of the furnace. In the old charcoal furnaces smelting rich ores the hearth was narrow, yet the operations comparatively were very successful. But in the present furnaces using coal and coke, the width is greater in proportion to the diameter of the boshes. Where raw coal is used, the hearth is wider than with coke. The size of the pieces of fuel to be used must be taken into consideration, in determining the size of the hearth. A few of the lumps of raw coal charged into some of the present furnaces, would stop the descent of the materials in the old narrow hearth.*

The structure and density of the fuel requires to be taken into consideration; for since the qualities of the fuel principally regulates the density of the blast, the breadth of the hearth should be suited to the density of the blast which the coke is capable of carrying. Hence, with weak cokes a narrow, and with strong cokes a wider hearth, will be most advantageous.

In Scotland the width varies from 6 to 8 feet;—the coal furnaces at Langloan and Kinniel are 6 feet; those at Dandyvan 7 feet; while the Muirkirk new furnaces are 8 feet. The hearths of Staffordshire coke furnaces are narrow,—from 2½ to 3½ feet. In the Welch furnaces the width varies from 5 to 8 feet; the Aberamman and Ystalyfera are 5 feet; the Sirhowy 5½ feet; Tredegar 6 feet; Plymouth 7 feet; and Dowlais 6 to 9 feet, according to the size of the furnace.

* In the charcoal furnaces, the hearths are usually about 2 feet square; but the largest diameter of the furnace rarely exceeds 9 feet. Charcoal is of too weak a structure for a dense blast. In the Swedish and Russian furnaces the hearths are narrow, and the mechanical arrangements for supplying blast very defective; yet if we consider the character of the fuel and low density of blast employed, we must allow, that in these furnaces, the narrow hearth is the most advantageous.

When coke is used as fuel, we are of opinion that a width of 6 feet is sufficient for all purposes; but with coal, with full size furnaces—16 to 19 feet across the boshes—we consider 7 feet as more advantageous. With a full volume of blast, at the requisite density, a maximum produce of iron will be obtained with hearths of these dimensions.

The height of the hearth to the junction with the boshes is subject to nearly the same variation as the width. In the Welsh furnaces, the height varies from 6 to 10 feet; at the Tredegar and Aberamman furnaces it is 6 feet; at the Plymouth 6½ feet; in the Anthracite furnaces 6 to 7 feet; the Pentyrch furnaces 10 feet, at the Dowlais furnaces from 7 to 9 feet. In Staffordshire they are from 5 to 7 feet; and in Scotland 5 feet appears to be the most common dimensions.

We are disposed to consider 5 feet as the most advantageous, a greater height can be attended with no advantage in point of economy, or produce, but may considerably reduce the smelting power of the furnace. If the hearth is carried high up, the capacity of the furnace is proportionably diminished, and its powers of producing a given quantity of carbonated crude iron reduced in a similar ratio. In some of the 18 feet furnaces the hearths are built 10 feet high for an interior capacity of 275 yards. Were they built 5 feet only, the difference—premising that the other dimensions remain unaltered—would give an additional capacity equal to the space contained in a circle 18 feet diameter by 5 deep—minus, the reduced size of the hearth; or nearly 40 cubic yards. Hence, by reducing the height of the hearth, the capacity of the furnace is augmented one-seventh; or from 275 to 315 cubic yards. The smelting power of the furnace being equal to 9½ cwt. per yard capacity, the enlargement would augment the produce, 19 tons weekly.

The width of the hearth at top, is in some instances, the same as at the bottom—the walls being built vertically; but in other instances they widen considerably in the ascent. The necessity for any considerable enlargement upwards is not very apparent. It tends to retard the descent of the materials. Where the hearth is wide this may be advantageous, inasmuch that it lightens the pressure on the bottom. In the usual width, however, the boshes support the weight of the materials, and the perpendicular pressure on the hearth is not great. On the whole a batter of 1 inch to the foot may be advantageous in the majority of furnaces. In the Tredegar and other furnaces, it is 1½ inch, but this appears to be a maximum amount.

An enlargement at the top facilitates the ascent of the gaseous products of combustion, and reduces the velocity in a region where the quality of the crude iron is principally determined. The ascending gaseous column increases rapidly in bulk in the first two feet of ascent, and requires additional space.

Commencing from the hearth, the boshes proceed in a straight line to the largest diameter of the furnace, forming as it were the frustum of a cone, the smallest end joining the hearth. The angle with which the boshes rise is a matter of considerable importance in the successful working of the furnace; for while it should not be so steep as to throw too great a pressure on the hearth, it should have a sufficient elevation to insure the uninterrupted descent of the materials, as fast as the lower strata are reduced in the hearth below. In determining the most advantageous angle, the nature of the ore and fuel require to be taken into consideration. If the ores are of a dense character and the fuel light the angle is usually very steep.

In practice it appears from the measurements of numerous furnaces that the flattest boshes lie at an angle of about 60°, while the steepest rarely exceeded 80°. At the Dowlais works there are boshes at 68, 74, 76, 78, and 81; the steepest are in the smallest furnaces, and it is worthy of remark, that these produce, for the same capacity, the largest quantity of iron. At the Plymouth furnaces the angle is 55°; Tredegar furnace, 69°; and Sirhow, 71°. The Scotch furnaces present considerable uniformity; the angle at Dandyvan is 69°; Kinniel, 71°; and Muirkirk, 72°. In the Alfreton furnace, Derbyshire, the angle is near 62°. The charcoal furnace hearths are constructed with boshes at 76 to 78°.

The boshes were formerly constructed at a low angle,—50° was not unusual; but in modern furnaces the rise is greater, and the alteration has been most beneficial. A less angle than 70° should not be adopted when the full smelting power of the furnace is desired. On a slope of 38°, the tendency of the materials to slide down is nil; at a greater angle the tendency is in proportion to the increased elevation. With the angle of 38°, the regular and equal descent of the materials in the furnace cannot be insured. The central column resting on the hearth descends fastest; the surrounding cylinder of materials resting on the boshes at a slower rate; while the materials immediately above the boshes fall into the hearth with the least velocity.

But while avoiding flat boshes, we must not run into the opposite extreme of constructing them unnecessarily steep. By using a greater angle than 70°, the boshes rise so high in the furnace that the capacity is materially reduced without any attending advantage.

Of late years much discussion has arisen respecting the contour of the section of the hearth and boshes; some writers maintaining that the hearth walls should rise perpendicularly, or nearly so, from which the boshes should start off at the desired angle; while others maintain, that the interior vertical section of the hearth and boshes should be formed by a straight line, starting at a given width at bottom, and continued to the side of the furnace at the desired angle. The walls of the hearth fall back with

the same angles as the boshes; the distinct angular junction of the two is consequently lost.

The advocates of this form of hearth give as a reason for its adoption, that it approaches the nearest to the form observed in furnaces which have been blown out after working several years. This has been considered a sufficient reason for constructing the hearth and boshes after the form thus produced by the continued action of the materials on the interior of the furnace.

Acting on this view of the subject, some ironmasters have altered the construction of the hearths and boshes of their furnaces to these lines, it is stated, with considerable advantage in respect to the yield and produce of metal. Among other works where they are used, we may mention the Sirhowy, Ebbw Vale, and Aberyschan, in Wales; and the Corbyn's Hall in Staffordshire, to the proprietor of which, the merit of introducing to the trade this description of hearth is due.

The adoption of this form of hearth by several iron-masters, shows in a striking manner, the little attention bestowed on the correctness or otherwise of the reasons adduced in its favor. At first sight the form which is produced by the continued action of the furnace may seem the most correct, but on further examination the fallacy of this argument is made apparent. If this form were the best, a furnace should work better after being in blast some years, for the improved form then would be attained, than when new, but in practice it is otherwise. Furnaces constructed with properly proportioned hearths, and boshes at a moderately steep angle will, if carefully blown in, produce as much metal, and be in as good working condition at the end of 3 months, as at any future period. We believe it to be different with the very narrow hearths common in Staffordshire; but this must be attributed to the error of dimension. Increase the size of these hearths to not less than two-fifths of the diameter of the furnace, and the produce of metal and yield of materials will be at a maximum, a few weeks after blowing in.

During every year that the furnace is in blast, a portion of the hearth and boshes is removed by the attrition of the descending materials; in a few years the boshes are worn down flat, the hearth enlarged, and the working of the furnace rendered more difficult; the yield of materials increases, while the make diminishes. Similar effects are observed in new furnaces when the blowing in has been hastily done, and the power of the furnace injuriously forced to the production of a large quantity of metal before the surrounding brickwork has been thoroughly glazed and heated. In either case when the boshes are much worn, the greater consumption of materials, and diminished make, progresses until the expense of manufacturing is augmented to an extent which renders blowing out and repairing absolutely necessary. If then the hearth and boshes are correctly proportioned at first,

the furnace will work best while they remain to those proportions; if they are improperly constructed, the wear caused by the descending materials may empure their original construction; but if it is usual with the Staffordshire ironmasters to leave the proper form of hearth and boshes to be effected by the descending materials, the disadvantages of bad yields and inferior makes will naturally follow.

We freely allow, that for a limited period this form of hearth produces the largest quantity of metal, and works to a good yield; and when it is considered that the straight lined hearth, and boshes, give about one-eighth greater capacity to the furnace, any other result could not be expected. But we must state that the wear of the brickwork of the hearth and boshes proceeds as rapidly as in the other construction; consequently, every year that the furnace is in blast, the boshes are flattening, the hearth enlarging, and the yield and produce deteriorating. It does not matter at what angle the boshes are set, so it is less than a right angle; the wear of the brickwork—premising that the furnace has not been improperly managed—goes on at a stated rate for each year; hence, if the hearth is unnecessarily large at first, and the boshes brought down to a low level, a so much shorter period will elapse before blowing out and replacing with new.

If this form of hearth and boshes is to maintain its efficiency unimpaired by the descending materials, the laws of friction and abrasion must be suspended in its favor,—something of this kind its advocates would seem to imagine really occurs. Among the objections urged against the old form of hearth with vertical walls, the inventor of the improved hearth states as a general fact, that one third of the substance of the hearth and boshes is carried away in the first six months' working, leaving it to be inferred that with the improved hearth the brickwork is not reduced in substance. If the hearth is excessively narrow, the heat maintained may be so intense as to soften the brickwork, and render it less able to resist abrasion; but this cannot occur with a wide hearth, though built with vertical walls. In what respect, then, is the improved hearth superior to the one commonly used in Wales and Scotland? Unless we grant its exemption from the wear produced by the descending materials, and we are aware of no one circumstance which can warrant such an assumption, the alleged superiority of this hearth seems to rest entirely on mere assertion.

The statement that one-third of the substance of the hearth and boshes is carried away in the first six months is very wide of the mark. That instances may have occurred in which this quantity has been removed in a much shorter period we are prepared to allow; but that such is the rule instead of the exception is manifestly incorrect. It takes on an average from 10 to 12 years. From the dimensions and working of numerous furnaces

built under our immediate superintendence, we have ascertained that the loss, after being in blast 4½ years, is not more than one-eighth of the original substance of the hearth and boshes. And as evidence that this was not carried away on the first blowing, we may mention that in the case of a furnace blown out after being in blast 17 months, the loss was still less in proportion to the time it had been at work. The brickwork at the junction of the hearth and boshes was rounded off, but in other respects the hearth and boshes of this furnace were so little the worse for the 17 months' blowing, that it was put in blast again without any repairs, and continued under blast for a further period of 8 years.

It is maintained by some theoretical writers on ironmaking, that the boshes do not wear; but since they disappear after a long blowing, it is very evident that they either melt or wear away. If we admit that the material of which they are composed melts, we must account for the presence within their compass of a temperature greatly above that required for fusing the ore; and as this cannot satisfactorily be done, we must seek for a solution in the friction produced by the descending materials. When the immense quantity which annually slides over the boshes is considered, we are surprised that the abrasion does not destroy them more rapidly. At a moderate calculation each foot surface is abraded by the contact of nearly 1000 tons, sliding under a pressure of 2 to 3 tons per square foot, every year of their duration.

It is very rarely that opportunities occur for ascertaining the wear of the boshes; for, except under peculiar circumstances, a furnace is not blown out until they are nearly, if not altogether, destroyed. Circumstances, however, which occurred at the Dowlais works in 1848, resulted in the blowing out of furnaces that had not long been in blast; opportunities, therefore, were afforded for measuring the direct loss which had taken place during the period they were under blast. In one furnace which had been under blast 4½ years, and averaged 116 tons weekly during that period, the deficiency, measured at right angles to the slope, was 11 inches. This is at the rate of nearly 2½ inches for each year in blast. At another furnace, which had been in blast about 17 months, the deficiency, as near as could be measured, did not exceed three inches. In both instances the wear was very regular; the original inclination of 70° was maintained, with a corresponding enlargement in the upper part of the hearth.

The duration of the boshes will vary with the quality of the material of which they are composed, and the mode of working the furnace. We find from 24 blowing-outs by the Dowlais company, that the average duration is 12 years; the longest period which any one furnace was in blast was 17 years, and the shortest 8 years, when blown out for repairing.

The diameter of the furnace at the boshes has been largely increased in some localities, but in others the diameter is not greatly above that prevailing in the last century. The furnaces of Staffordshire range from 9 to 14 feet; those of Scotland 12 to 18 feet; the Welsh anthracite furnaces 10 to 14 feet; in other parts of the South Wales district the diameter ranges from 13 to 19 feet. The new furnaces at the Rhymney, Dowlais, Hirwain and Plymouth works, from 18 to 19 feet, and certainly are the largest hitherto constructed. But the diameter of the furnace is a mere matter of opinion. If they are large, the consumption of materials and blast is in proportion to the increased capacity and produce; and the cost of erecting is greater, though not to the same extent. The most advantageous dimension will be regulated by local circumstances.

Furnaces of 12 to 14 feet in diameter are preferred by some ironmasters as being more manageable than larger ones. But as the controlling influence is exerted through mechanical agents, we do not see how small furnaces are superior in this respect to those of the largest calibre. Alterations in quality or produce are dependent on the descent of the materials; this being equal, the time required in alterations will be the same, whether the furnace be large or small. The interior of the hearth may be more accessible to the workmen, but the difference in the linear dimension is not great. In one respect, however, small furnaces are advantageous, especially in small establishments; producing a smaller quantity weekly, the manufacturer has a greater command on the production of small quantities of metal of any particular quality.

The form of the interior from the boshes to the throat is subject to no fixed rule. In the majority of furnaces it is that of a frustum of a cone. In some instances the interior is carried up vertically for a short distance above the boshes, but it is more common to see it formed by a straight line to the throat. When a greater capacity is desired, a curved line is substituted for the straight; the centre for striking this curve generally is on a level with the top of the boshes, and the radius is adjusted that a regular curve may touch the boshes and throat.

An enlargement of the furnace above the boshes, thereby augmenting the capacity, is adopted as an improvement by some ironmasters; but as this is merely a continuation of the boshes in the lining of the furnace, while we allow the utility of greater capacity, we doubt the expediency of constructing any of the lining exposed to the materials in this manner. Wherever it is done the wear will be equally great with that going forward in the boshes, and must occasion the renewal of this lining in a nearly similar period of time. But the renewal of the lining of a furnace, besides being very expensive, is a dangerous operation. Built vertically, or with an inclination inwards, the wear on the

lining is inconsiderable; after 20 years' blowing we have not found the bricks shortened more than 3 to 4 inches. If greater capacity is desirable, the object will best be attained by building the furnace of a sufficient diameter.

A large number of the Scotch furnaces are constructed with a considerable part of the interior cylindrical, or only slightly coned. The height of the cylindrical part is sometimes more than twice the largest diameter, though generally much less. The body at top is rapidly drawn in to the diameter of the filling throat, diminishing at the rate of 6 inches in the diameter for each foot of height, till the desired contraction is attained.

The cylindrical form, though general in Scotland, does not, in our opinion, possess any superiority in point of produce or yield over the others, beyond what is due to the greater capacity afforded by this construction. For the same consumption of building material, probably it gives the largest capacity; in this respect then it must be considered more economical than any other. The rapid enlargement under the throat is favorable to the use of raw coal of a weak character. If the sides expanded at the rate common in many districts, the great updraught would cause a large consumption of the fuel in the vicinity of the throat, and frequent scaffolds.

There is an opinion current in Scotland that the large weekly makes obtained in comparison with the makes in other districts, is connected with this form of furnace; it would be more correct to ascribe it to the fusible character and richness in metal of the carbonaceous ores smelted.

The diameter of the throat or filling place is a matter of the greatest importance to the operation of the furnace. It influences the make and yield more than any other dimension; yet it receives little attention in the designing of the furnace. Local usage is generally considered the safest guide in a matter which above all others is likely to cause loss, and create difficulties in the way of successfully working the furnace.

In the old blast furnaces, the top invariably was very narrow, the breadth scarcely averaging one-fourth of the diameter of the furnace; and in Staffordshire, Derbyshire, and other districts, furnaces are in operation with throats bearing this proportion. In other furnaces in these districts, a width of one-third of the diameter of the furnace is considered sufficient. In Scotch furnaces erected or altered within the last twenty-five years, the width is near one-half of the diameter—extended however, in one or two instances, to as much as two-thirds. In the South Wales district, the width ranges from one-third to two-thirds of the diameter, but the most common proportion is one-half or nearly so.

Although it is now generally admitted by smelters that, with a narrow throat, a furnace will not carry so much burden, or otherwise work so well as with a wider throat, the largest hitherto

constructed have not exceeded ten feet. This seems to be considered a maximum width. But we would remark, if the enlargement from one-fourth and one-third has been productive of considerable advantage, what is to prevent a further enlargement being attended with corresponding advantage?

With the narrow-throated furnace formerly employed in smelting, the average yield of coal to the ton of crude iron exceeded six tons. By enlarging the throat to one-third, and employing a more powerful blast, the consumption was reduced to four tons; continuing the enlargement to one-half and it was reduced to two tons. With every allowance for the reduction effected through other improvements, we are of opinion that three-fourths of the saving in fuel is due to the enlargement of the throat; and that by continuing the enlargement a further saving may be effected.

In support of this opinion we may adduce the effects produced by a narrow throat at one of the Dowlais furnaces. The furnace was eighteen feet diameter at the boshes, and formerly worked with a throat of nine feet. It was blown out, new hearth and boshes put in, and a new lining carried up from the boshes, but on approaching the top the curve was quickened so that the throat was of the reduced width of six feet, or one-third the diameter of the furnace. Prior to the alteration the furnace had been in blast fifteen years, averaging 97 tons of pig iron weekly, with a consumption of 45 cwts. of coal to the ton. After the alteration the make was irregular, varying from 50 to 70 tons; the consumption of coal rose to 70, 80, and 90 cwts. per ton; even with this consumption the quality was exceedingly bad, and the loss of metal in the dense black scouring cinder produced, very great. The average yield of coal with this narrow throat was near four tons; but if the deterioration in quality is also taken into account, the consumption was just twice the quantity which sufficed with a wider throat. Yet the proportions adopted in this experiment may be seen in numerous English furnaces.

Unable to obtain more satisfactory results, the materials in the furnace were let down nearly to the boshes, the upper part of the lining taken out and placed further back, so that a throat of near the usual width—9½ feet—was obtained. With this enlarged throat the make for several weeks has exceeded 172 tons weekly, and for a period of six months, has averaged over 160 tons, with a good yield of coal and materials.

There was one other circumstance, connected with the working of this experiment, worth recording. Whenever the furnace was let down a depth of seven or eight feet, and maintained at this level by the fillers, the yield and make greatly improved. The former would be so low as 50 cwts. while the latter rose to 90 tons. The superior produce, when thus let down, clearly pointed to the confined throat as being the cause of the unsatisfactory re-

sults. At the reduced depth the enlarged diameter of the furnace must be considered as the throat. We have witnessed similar effects in other narrow throat furnaces, which have worked best when the surface of the materials has been kept a few feet below the charging plates.

If a brief consideration be given to the changes effected in the fuel in the upper regions of the furnace, the impolicy of using a narrow throat must be apparent. To show that a large consumption of the fuel takes place in the vicinity of the throat under such circumstances, we need only refer to the greater draught created, as a sufficient cause for the diminished reducing power of the fuel in the lower regions. The volume of the ascending gaseous column being the same, the velocity of escape through the throat will be in an inverse ratio to its area. Hence, the velocity with which the ascending column passes the upper layer of materials into the atmosphere, may be calculated with sufficient accuracy to show the beneficial effects which would accrue from the general adoption of large throats.

We have shown that a furnace eighteen feet diameter at the boshes receives 7,370 cubic feet of atmospheric air per minute. To the air there must be added the carbonic acid of the limestone and the volatile gases emitted by the coal during distillation; the amount of these cannot be determined with accuracy, as they vary with the composition of the fuel; but, added to the volume of atmospheric air, the ascending gaseous column at the level of escape will measure 10,000 cubic feet. This is the volume at the mean temperature of the air before admission, but the temperature at the throat averages near 1,000°. The increase of temperature augments the volume—according to the law of Marriotte, at the rate of .00208 for each degree of temperature. At the temperature of 1,000°, the 10,000 feet of gas will be expanded into nearly 30,000 cubic feet.

If the eighteen feet furnace is provided with a nine feet throat, the area for the passage of the heated gases will be 63.6 feet; and the velocity of escape 472 feet per minute, Diminish the diameter of the throat to one-third—six feet—the area will be 28.3 feet, and the velocity of the issuing gases 1,060 feet. Reduce the diameter to one-fourth, or 4½ feet, the area will be 15.9 feet, and the velocity 1,868 feet per minute.

But the entire area of the throat is not available for the escape of the ascending column of gases; the space occupied by the descending column of solid material must be deducted. Looking at the comparatively dense manner in which the materials lie in the furnace—the ore and broken limestone filling the interstices between the pieces of fuel—five-sixths of the area is occupied by the descending column. The area being diminished to one-sixth, the velocity of escape is increased in an inverse ratio; in the nine feet throat it is 2,832 feet per minute; in the six feet throat

6,360 feet; and in the 4½ feet 11,208 feet per minute: calculated per second, the velocities are 47, 106, and 186 feet.

Now thirty feet per second is a high velocity for the air entering the fire-places of steam-engine boilers, burning 15lbs. of coal per hour for each square foot of grate; yet in the case of blast furnaces we have the fuel exposed to a much greater draught the instant that it is precipitated into the furnace. With the large size throat the draught is one half greater; but with the small throat it is six times that under engine boilers. With such rapid draught, then, can it be a matter of surprise that a considerable portion of the fuel is consumed in the throat? Or that the temperature at the mouth of the narrow-throated furnace is higher than at one having a wide throat?

The consumption of fuel in the throat through the intense draught maintained, explains the superior produce and yield when the materials are let down a few feet. The enlarged area of the furnace at the lower level affords a larger area for the ascending column of gases; consequently, they pass through the upper stratum of materials with a reduced velocity, and their escape through the narrow throat is not impeded by a descending column.

We will adduce another fact well known to smelters, as a reason for enlarging the throat. Furnaces are observed to work remarkably well during the blowing out. This has been seized on by some writers as a reason for building furnaces of a less height than usual; but whatever be the height or diameter, the production of carbonated crude iron from the majority of ores, involves the necessity of the ore being in the furnace forty hours, and any reduction of capacity by diminishing the height will be followed by a similar reduction in the make. We consider it a result of the diminished temperature of the upper layer of materials; the area for the passage of the ascending gases enlarges as the level descends; their velocity thereby is reduced; a lower temperature prevails; and a larger proportion of the fuel is available for combustion in the hearth.

The utility of reducing the diameter of the furnace at top may be fairly questioned. The throat appears to have originated from an erroneous impression that the furnace could be filled best through a contracted orifice. It was supposed that the commingling of the materials, so essential to the production of superior iron, was ensured by charging through a narrow throat; but that wider throats did not afford equal advantage. The increase of width, lately however, has demonstrated that furnaces may be properly filled with wide throats.

By some writers on ironmaking the contraction is asserted to be beneficial, inasmuch as it retains the heat, and thus prevents a large waste of the calorific powers of the fuel; others advocate a considerable arching of the top, on the score of reflecting the heat

back on the materials. This principle was carried to its full extent at the Wingerworth furnaces, but it is scarcely necessary for us to say with what success. The abandonment of the plan, and altering the furnaces back to the usual form, would not have been done if the economy of fuel and other advantages claimed for it really existed. The advocates for concentrating the heat at top, and reflecting it on the materials, should bear in mind that, maintaining a high temperature at the top involves the consumption of a portion of the fuel in a region where its combustion can be of no service to the operations of the furnace.

The importance of a cool top on the produce and yield of the furnace is understood by some ironmasters, but the means by which they accomplish this desideratum are original. Instead of widening the throat (the only legitimate remedy), when the top is working hot, they use wetted coke. For the vaporization of the water thus introduced into the furnace, a portion of the fuel is expended, but not so much as would be lost by the higher temperature.

The height of the furnace from the bottom of the hearth to the level of the charging plates at top, varies considerably in the different districts. The lowest elevation is observed in the anthracite furnaces on the western side of the Welsh district. The average height of the anthracite furnaces is under 40 feet; 36 feet is a common height, but a large number are under 30 feet. In the central and eastern portions of the same districts, the height ranges from 42 to 48 feet. The Staffordshire furnaces probably are more irregular in this dimension than the others—they range from 40 to 60 feet—the last may be considered as the highest furnaces at work in this country. In Derbyshire they are between 40 and 45 feet; in Scotland between 40 and 46 feet.

The other conditions being similar, the height of the furnace should be regulated by the susceptibility of the ore to receive the carbonating principle. Ores devoid of carbon, chemically and mechanically, will be smelted more economically, and be converted into a superior description of pig iron in lofty furnaces; but with furnaces of small elevation the quality will be inferior. By a lengthened exposure to the carbonizing influence of the ascending gaseous column the ore is partially supplied with carbon, by which its reduction in the hearth is greatly facilitated. Hence silicious, calcareous, and other ores containing a minimum percentage of carbonic acid should invariably be smelted in furnaces above the average height.

The more fusible character of the ores of the argillaceous class, enables them to be reduced with furnaces of an average height. The large percentage of carbon, chemically, with the metal in all the carbonates of the coal formations, very much facilitates their reduction, and unquestionably influences the quality of the metal. Where it is wanting, the general refractory character of the ore is well known to the ironmaster.

The reduction of the argillaceous ores is effected in the anthracite district in low furnaces, but no sufficient reason has appeared for their use. The limited scale on which operations at one time were carried on in this district may account in part for the small dimensions of the furnaces. And when smelting with anthracite was not understood so well as at present, it was considered that, owing to the dense character of the coal, the blast would be unable to penetrate a column of materials of the height usual in other districts. But furnaces of larger dimensions would be more advantageous. This is now partly understood by the proprietors, and the elevation in some instances has been increased—at the Ystalyfera works for example—10 or 12 feet.

The very fusible character of the carbonaceous ores, and the excess of carbon in combination, result in the production of carbonated crude iron under almost any circumstances. With the present furnaces it is produced in about two-thirds of the time required for argillaceous ores, and one half of the time for silicious ores. Yet we observe that the Scotch furnaces working carbonaceous ores are uniformly of a maximum height; quite as high indeed as those used in Wales for an ore melting at a much higher temperature, yielding a lower percentage of iron, and producing carbonated crude iron only, with careful management. Judging from the results obtained in Wales, the Scotch furnaces appear unnecessarily high for the character of the ore.

The cause of this superior elevation of the Scotch furnaces may be accounted for in the general substitution of the carbonaceous for the argillaceous ores formerly used. A considerable number of the existing furnaces were originally constructed for smelting the argillaceous ores; these furnaces have served as models for the construction of others in recent years. The elevation which long experience had demonstrated as being the most suitable for the argillaceous, was retained for smelting the more fusible carbonaceous ore. Alterations have been made in the breadth of the hearth, and diameter at boshes and throat, to meet the change from raw coal to coke; but alterations in form also might have been made with considerable advantage on the change of ore.

To the use of such high furnaces for the reduction of the most fusible ore known, must be attributed a portion of the comparatively high consumption of coal. Of a highly combustible character, a large portion of the calorific power of the fuel is unprofitably expended in the upper regions; the remainder suffices for the requirements of the ore, previously surcharged with carbon; hence, the true extent of the immense waste of carbon going on in these furnaces remains undiscovered.

(To be continued.)

Art. II.—MINING STATISTICS OF GREAT BRITAIN.*

The total quantity of Tin Ore (block tin) raised in Cornwall and Devonshire, from January to December inclusive, in 1855, was 8947 tons, of which quantity Devonshire produced about 320 tons. The average price of the ore per ton was 68*l*., making the actual value of ore sold 608,396*l*. The produce in metal was as nearly as possible 6000 tons, and the mean average price of all varieties 120*l*.; consequently, the total value was 720,000*l*. Thus, there has been a small increase in the produce of the tin mines; the quantity of tin ore sold in 1853 being 8866 tons, and in 1854, 8747 tons. The importation of tin in 1855 was 1612 tons, being 639 tons less than in 1854; the exportation of English tin varying but very slightly for the last three years, and being in 1855, 1387 tons.

At the Cornwall Ticketings, there were sold during 1855, 195,193 tons of Copper Ore, being 10,335 tons above that of 1854. The average percentage produce of this ore was nearly 6¾, the produce in metallic copper being 12,578½ tons, and the money value 1,263,739*l*. 6s. The sales at Swansea from the Irish copper mines were 12,381 tons of copper ore, and 1157 tons of copper, the value being 125,981*l*. 3s. 6d; and from Welsh mines 177 tons of ore and 9¾ tons of copper, value 1312*l*. 13s. From Roughtengill Mine, in Cumberland, were sold 14 tons of ore, giving 1 ton 8½ cwts. of copper, of the value of 141*l*. 9s.; and from Helvellyn, in the same county, 5 tons of ore, and 12½ cwts. of copper, value 75*l*. 10s. From Devonshire, the Queen of Dart Mine sent 124 tons of ore, producing 7 tons of copper, value 435*l*. 5s.; and Molland Mine 83 tons of ore, producing 6 tons 2 cwts. of copper, value 648*l*. 12s. The produce of foreign mines sold at Swansea amounted to 28,982 tons of ore, giving 4650½ tons of copper, and realizing 517,550*l*. 10s. The slags sold amounted to 1556 tons, and realized 5852*l*. 5s. 6d. The returns for Irish mines, therefore, showed an increase, whilst those of Wales have diminished. The increase in the sale of foreign ores was 6650 tons. The purchases by private contract are more in detail than they had hitherto been; the principal items being—Coniston Mine, Cumberland, 3365 tons 7 cwts.; Llandudno, Carnarvonshire, 1673 tons 13 cwts.; Ballygahan, Wicklow, 1353 tons; and Ballymurtagh, Wicklow, 1329 tons. The total quantity of copper purchased by private contract was 7440 tons 18 cwts.

Of Lead Ore, there were 92,330 tons raised from the mines of the United Kingdom; this yielded of lead 73,091 tons, and from which there was separated of silver 561,906 ozs. The mean average of all purchases being 14*l*. 4s. 6d.; the total value of the

* Robert Hunt.

lead sold was 1,311,971*l.*; the mean average for the year for pig-lead was 23*l.* 4s.; this shows the total value of pig-led produced in 1855 to be 1,692,055; the value of silver, at 5s. per oz., was 140,476*l.* Of foreign silver ore there has, during the year, been imported and sold at Liverpool and Swansea 7222 tons, producing 2,112,246 ozs. of silver. The importation of lead has fallen off 4627 tons, and the exportation increased 2748 tons, from the quantities imported and exported in 1854.

The details of Iron Ore produce are given for the first time, the estimated total quantity raised in the United Kingdom being 9,553,741 tons. This supplied 311 blast-furnaces in England, 157 in Wales, and 122 in Scotland. The produce of pig-iron for the year ending December 31 was 3,218,154 tons. The mean average price of pig-iron during the year, embracing the varying prices on the Clyde, the more uniform price of Welsh iron, and the variations of price in Yorkshire and Staffordshire, has been 4*l.* 4s. per ton; consequently the market value of the pig-iron produced has been 13,516,266*l.* In the imports of iron there has been a falling off of 4777 tons, while in the exports there has not been any remarkable variation. The exports from Liverpool to the United States have decreased 90,164 tons, and from the same port to British North America 17,915 tons.

The number of Collieries at work in 1855 were—In England, 1881; Wales, 310; Scotland, 403; Ireland, 19; the total produce of the coal-fields of the United Kingdom being 64,453,070 tons, and showing a decrease of 207,331 tons from the previous year. Of the quantities carried coastwise, there was a decrease respectively as follows:—Coals, 391,588 tons; coke, 18,424 tons; anthracite, 15,011 tons; patent fuel, 12,651 tons; whereas on the exports of coals the increase has been—Coals, 643,251 tons; coke, 28,855 tons; and patent fuel, 34,540 tons. The diminished consumption of coals at home is strikingly shown in every district, the high price of provisions inducing a greater economy in the use of fuel.

The increasing value of the sulphurets of Zinc has naturally led to a considerable increase in the production of the ore. The returns show of Calamine 182 tons 3 cwts., and of Blende 9620 tons 16 cwts. The above list is not to be regarded as representing all the "Black Jack" raised, but the quantities sold from the 19 mines from which returns have been made. The Zinc imported into the United Kingdom in 1855 was 17,845 tons, against 19,583 tons for 1854, and 23,419 tons for 1853; and the exports in 1855 were 2516 tons of British, and 2635 tons of foreign.

THE SALT TRADE.

Cheshire.—The quantity of white salt manufactured from brine in the districts of Winsford and Northwich, in the year

1855, was 834,514 tons. Rock salt, exported as such, 70,256 tons. The quantities of salt carried down the River Weaver from April 5, 1855, to April 5, 1856, were—Rock salt, 53,256 tons; white salt, 708,358 tons.

Worcestershire.—The quantity of salt manufactured from brine at Droitwich and Stoke, in the year ending Dec. 31, 1855, was 170,000 tons.

Exports.—Of British salt, there was exported in—

1853,	Bushels, 20,850,960	Value, £272,173
1854,	19,543,360	293,473
1855,	25,206,127	347,714

Ireland.—Carrickfergus, near Belfast, 20,000 tons. Of this quantity, 8000 tons were consumed in Ireland. No refined salt is exported, the trade being confined to rock-salt. The salt trade of Belfast is extending; large contracts for the current year have been entered into with soda manufacturers in Scotland and in Northumberland.

SULPHUR ORES—(MUNDIC—IRON PYRITES.)

The largest supply is from the mines of Wicklow, in Ireland; and the following mines shipped from that port and Arklow—

Ballymurtagh,	Tons, 17,185
Ballygahan,	12,222
Conorree or Connary,	8,426

The total quantity exported, the produce of Ireland, has been 58,000 tons.

Trefriw, near Llanrwst, North Wales,	Tons, 200
From numerous mines in the Counties of Devon and Cornwall, shipped at Devoran, Portreath, Hayle, &c.	19,840
Cumberland and Westmoreland,	2,000
"Coal Brasses," chiefly Durham and Northumberland,	1,780

ARSENIC.

The difficulty of ascertaining the actual quantity of arsenic produced from our mines annually is great. This arises from the circumstance that much arsenic is sold from the "burning houses," as white oxide of arsenic, while some mines sell arsenical iron ores (arsenical mundic) in small parcels, which are returned as arsenic.

The produce, however, of white oxide of arsenic, for 1855, in Cornwall, has been computed as carefully as possible to be 1390 tons.

The following mines have furnished exact returns :—

	Arsenical mundic.	White arsenic.
Okel Tor. Calstock,	Tons, 151	Tons, —
Bedford United, Tavistock,	197	—
Boringdon Consols, Plumpton,	147	—
Dolcoath, Camborne	—	102
Wheal Unity Consols, Gwinear,	—	106
Carn Brea, Redruth,	—	140
East Pool, ditto,	—	84
Wheal Sidney, Plympton,	—	11

NICKEL AND COBALT ORES.

Cornwall.—St. Austell Consols, 39 tons.

Scotland (*Argyleshire.*)—Mines belonging to the Duke of Argyll—from these there appears to have been raised, but not all sold, during the last two years, 800 tons.

Cumberland.—The Coniston Mines, 3 tons.

BARYTES.

The Isle of Arran, 550 tons; Barytes Company of Ireland, 1291 tons; Alston Moor, 104 tons; Bridford Consols, Devonshire, 35 tons.

ART. III.—CINNABAR IN SPAIN.*

THE indications of cinnabar are very numerous in the carboniferous formation of the Asturias. It occurs indifferently in the mountain limestone, in sandstone, and in the black schist, and is occasionally intimately associated with the coal itself, having been evidently injected by sublimation. In no case does it form part of a regular lode, but appears either as a pipe vein, as in the limestone, or it impregnates a bank of schist, the sublimation having been effected, apparently, conformably with the strata. Several mining companies have been projected for the working of the cinnabar and the extraction of the quicksilver in and near the villages of Mieres and Pola dè Lena. In the first line stood the Anglo-Asturian Mining Company; it possessed five mines, but only one of any importance. This mine is situated near a miserable cluster of houses, called Munon, about one league from Pola de Lena. It is known by the name of La Eugenia. The cinnabar ore, associated with a large quantity of realgar crystallized carbonate of lime, and an argillaceous limestone, forms an almost perpendicular pipe vein in the limestone; its form in detail is that of a series of pockets, joined by narrow necks, as in the case of some lead deposits. In the levels several small lateral branches have been cut, and also a clay run, which contained a large quantity of pure cinnabar, in the form of rolled pebbles, very smooth on the surface, and bearing the evident marks of the action of water. A thin seam of impure coal was also intersected, which contained a very notable quantity of cinnabar. The great bulk of the cinnabar is associated with realgar, or sulphuret of arsenic, both of these minerals being nearly pure, and the latter at least eight times more abundant than the former. The

* London Journal.

cinnabar presents no traces of crystallization, and yet I have been unable to discover any traces of arsenic in very clean specimens that I tried for that metal; nor, on the other hand, have I been able to detect any mercury in the realgar; this latter mineral has an apparently crystallized structure.

The works in this mine, from the very nature of the deposits, are extremely irregular, and certainly, as a whole, the mine presented (1851) no encouraging feature. The present low price of quicksilver must have considerably damped the ardor of the cinnabar miners.

The ore in the Eugenia Mine has been dressed by the processes usually employed for copper and lead ores. In spite of the high specific gravity of the cinnabar, it possesses, like several other ores, when in a comminuted state, the property of floating on water, and this occasions a considerable waste in the fine sized and crushed ore, subject to the action of water. This process is undoubtedly very vicious, and it would have been preferable, had circumstances permitted it, to have reduced the ores on the spot, and have thus avoided the greater part of the water dressing, the principal object of which is the reduction of the transport cost. The metallurgical treatment of poor quicksilver ores presents no difficulties whatever; it is more a question of cost of labor and fuel than a loss of metal. The common run of wages in the mine was as follows:—for miners, 5 to 6½ rials per day; laborers, 4 rials; boys, 1½ to 2½ rials; and women 2½ rials. The rial is worth about 2½d.

The other mines of this company have only produced some few tons of ore, and the prospects are not cheering.

The quicksilver reduction house of the Asturian Mining Company is situated within the same inclosure as the iron works. The process followed is that of reduction by quicklime, in cast-iron retorts. The ores brought to the works for reduction vary much in the proportion of arsenic and cinnabar they contain, and the dose of lime used is in proportion to the sulphur contained in the two sulphurets to be decomposed by the joint action of the lime and heat.

Except in very small parcels, the ores treated never contained beyond 12 per cent. The average of the picked ore was about 5 per cent; the ragging and water-dressed ore, 4 to 10 per cent; and in many cases, when the carriage of the ore from the mines was low, I have found it advantageous to treat ores of 2 and 3 per cent. without further mechanical preparation. The dried ore is ground by an edgestone mill to a tolerably fine powder, and the quicklime is ground still finer, under the same mill. The latter is ground every two days, and preserved in covered boxes, with the view of preventing the absorption of water, and the conversion of the quicklime into hydrate; this hydrate is particularly troublesome during the distillation, from the evolu-

tion of abundant vapors, which invariably cause a loss in the mercury. This metal is remarkably susceptible of volatilization, and of being retained in the form of vapor, even at comparatively low temperatures, by the action of the vapor of water.

The mixture of the ore and quicklime is effected on the floor of the retort-house, by means of a shovel. The retorts, previously brought to a red heat, are then charged with this mixture in much the same manner that gas retorts are charged in this country. The first retorts mounted on these works were large and D shaped, weighing about 30 cwts. each. They were mounted and first put to work by the Messrs. Manby, and answered the purpose very well. The delivering tube is formed of a projecting nozzle, 7 in. square, to which is bolted a T piece, forming with its long arm a tube, descending to a cast-iron recipient; both short arms are flanged, the one side being bolted to the retort nozzle, the other having a door screwed and luted on; the object of this door is to admit a clearing bar when the nozzle becomes, as it often does, choked by metallic arsenic. The charging orifice of the retort is secured by a cast-iron door, luted on with clay, after the manner of a gas retort. The cast-iron receiver is partly filled with water, so as to form a slight water joint.

The general composition of the cinnabar ores, as resulting from a great variety of analyses, are as follows:—

Bi-sulphuret of mercury, . . .	2 to 12	per cent.
Realgar, or protosulphuret of arsenic, . .	2 to 40	"
Carbonate of lime, as limestone and crystallized spar, together with clay, forms the bulk of the ore.		
Iron pyrites, ...	½ to 5	"
Coal, a small quantity.		

Before making the charges, the retorts are raised to a distinct red heat, and constantly maintained at the same temperature. The first effect of the heat is to drive off the water contained in the charge, the second to sublime a portion of sulphuret of arsenic, in the shape of a dirty yellow powder; after that commences the decomposition of the sulphurets, and the distillation of the mercury and arsenic. The two metals are invariably mixed with a certain quantity of sulphuret of arsenic. I consider the perfect decomposition of this sulphuret on the large scale to be troublesome, however large an excess of lime may be used. If the ore operated upon is not rich, the greater part of the mercury will be found in the shape of minute globules, intimately mixed with the metallic arsenic, the latter in the form of a coarse powder.

As may be easily conceived, from the variable quantity of sulphurets in the ore, the duration of the distillation also varies for the same amount of charge. In actual practice, however, I have found it convenient to render the duration of the distillation invariable, and to vary the weight to the charge in such a way that the distillation should be always completed in the same fixed

number of hours. As fuel and labor are cheap, the small loss on these items was of very little consequence, compared with the loss of so valuable a product as mercury, which would have resulted from adopting irregular hours for charging and uncharging. The recipient house was kept constantly locked up, as the mercury was liable to be pilfered. The charge for each retort was sometimes as high as 400 lbs. If the ore contained but a small quantity of realgar, about 80 lbs. of quicklime would be used to the charge, and if it were very arsenical the charge would sometimes be 150 lbs. of ore and 150 lbs. lime. The retorts were uncharged and charged every morning at 6 o'clock. The uncharging commenced by taking down the small doors covering the T pieces leading to the recipient. The appearance of the inside of the nozzle of the retort, and the pipe leading to the recipient, varies according to the quality of the ore that has been treated; in some cases the nozzle presents a thick laminated coating of metallic arsenic, exceedingly hard, and showing a fracture more or less metallic and brilliant; lower down the tube, and attached to the sides, may be seen a crumbling mixture of metallic and sulphuret of arsenic, with globules of mercury, and at the bottom of the recipient itself, in the water, a mixture of arsenic, sulphuret of arsenic, and mercury, in a sandy and scaly form, and in a fine mud, mixed with globules of mercury. In the case of a rich ore, containing 45 per cent. mercury, and but very little arsenic, I have scooped out from the bottom of the recipient a dirty metallic-looking paste, in appearance very much like an amalgam of zinc, and which would take the impression of the finger, but on being pressed slightly in the hand, and allowed to remain a short time, became converted into fluid mercury, with a small quantity of a dark-colored powder floating on the top.

Immediately on the doors being opened, and the air allowed to penetrate into the interior of the retorts, a thick cloud of white arsenic rolls out, and partly fills the receiving room; two workmen immediately proceed with long chisels and hammers to the cleansing of the nozzles and elbows, by chipping off the solid encrustation. Generally speaking, it does not take a long time, but it is an operation extremely disagreeable to those men who have not been accustomed to it. The doors being luted and replaced, the workmen then proceed to the uncharging of the residues of the distillation. The large doors being taken down, and the interior of the retort exposed to the action of air, a large quantity of the vapor of white arsenic, with sulphurous acid, rolls forth, and fills the upper part of the retort house, and in windy weather completely envelopes the men. Of the little effect the arsenical vapor has upon their health I shall speak hereafter. The uncharging of the residue in the retort is effected by means of a long-handled iron rake; this residue is drawn into a sheet-iron box, mounted on wheels, and placed immediately under the

tion of abundant vapors, which invariably cause the form of mercury. This metal is remarkably susceptible of s at the point and of being retained in the form of vapor, even nts. The new low temperatures, by the action of the vapor long sheet-iron

The mixture of the ore and quicklime is e scoop to the fur- of the retort-house, by means of a shovel. thdrawing it on its ly brought to a red heat, are then charg pposite direction, and much the same manner that gas retorts he bottom of the retort. try. The first retorts mounted on th d by three men, and the shaped, weighing about 30 cwts. ea crewed on. first put to work by the Messrs. e distillation, the medley con- pose very well. The deliveri er (called "calejas," or heads, a nozzle, 7 in. square, to whi are scooped out of the water by its long arm a tube, descend l with holes, and the whole collect- arms are flanged, the one A portion of fluid mercury remains the other having a door pient, and is drawn off by a tap-hole, door is to admit a cl The "calejas" are then taken to a press, often does, choked been an hydraulic one, and submitted to a the retort is secur with a view of extracting part of the mercury the manner of a with water, so

The gen from a gre

Bi-sul Rea Ca

ART. IV.—DIRECTIONS FOR COLLECTING, PRESERVING AND TRANSPORTING SPECIMENS OF NATURAL HISTORY.* By Prof. JOSEPH HENRY.

§ I.—GENERAL REMARKS.†

THE general principle to be observed in making collections of Natural History, especially in a country but little explored, is to gather all the species which may present themselves, subject to the convenience or practicability of transportation. The number of specimens to be secured will, of course, depend upon their size, and the variety of form or condition caused by the different features of age, sex, or season.

As the object of the Institution in making its collections is not merely to possess the different species, but also to determine their geographical distribution, it becomes important to have as full series as practicable from each locality. And in commencing such collections, the commonest and most abundant species should be secured first, as being most characteristic. It is a fact

* Prepared for the use of Smithsonian Institute, and ordered to be published December, 1853.

† This chapter is intended especially for the guidance of travelling parties by land, and embraces many points referred to subsequently at greater length.

...n in the history of museums, that the species which ...bundance would be first expected, are the last to ...pearance. Thus, while the rarer mammals of the ...ably well represented, the antelope, prairie-dog, ...s of wolves, the black-tail deer, and others, so ...y accessible localities, have scarcely ever been ...te.

...procured, however imperfect, should be ...il a better can be obtained.

... part only of the specimens collected can be ...h species should be selected as are at least likely ...d in other localities or on other occasions. Among ... be mentioned reptiles, fishes, soft insects, &c.; in ...all such as require alcohol for their preservation. Dried ...cts, as skins, can be procured with less difficulty, and are frequently collected by persons not specially interested in scientific pursuits.

In gathering specimens of any kind, it is important to fix with the utmost precision the localities where found. This is especially desirable in reference to fishes and other aquatic animals, as they occupy a very intimate relation to the waters in which they live.

The smaller quadrupeds, of the size of a mouse, may be preserved entire in alcohol. Larger kinds should be skinned, and the skins put into alcohol, or coated on the inside with arsenic, and dried.

The skulls of the smaller kinds may be left in the skins; those of the larger should be removed, taking care to attach some common mark, by which they may be again brought together. Large animals, of or above the size of a wolf, may, for greater convenience, be skinned after the method pursued by butchers, by drawing the skin of the legs down to the toes, and there severing the joint. The skins need not be sewed up, as is directed for the smaller kinds, but rolled up into bales, after applying an abundance of arsenic and drying them. In the absence of arsenic, salt applied to the skin will answer as a preservative. Immersion in a strong brine of alum and salt will be found very efficacious. Powdered green or blue vitriol, sprinkled on the hair, will serve a good purpose in keeping off insects.

It is very important to procure the skeletons, and at all events the skulls, of all the species of mammals, in sufficient number to include all the variations of age and sex. These may be roughly prepared by cutting off the flesh, extracting the brain, and drying in the sun.

In passing through the breeding ground of species of birds whose nidifications and eggs are not known, attention should be paid to securing abundant specimens of nests and eggs. When possible, the skin of the bird to which each set of eggs may belong should be secured, as well as the skins of birds generally.

A great obstacle in the way of making alcoholic collections while on a march, has been found in the escape of the spirits and the friction of the specimens, as well as in the mixing up of those from different localities. All these difficulties have been successfully obviated by means of the following arrangement:—Instead of using glass jars, so liable to break, or even wooden kegs, so difficult of stowage, a square copper can should be procured, having a large mouth, with a cap fitting tightly over it, either by a screw, or otherwise. The can should be enclosed in a wooden box, or may be made to fit to a division of a pannier, to be slung across the back of a mule. Several small cans, in capacity of from a half to one-third of a cubic foot, or even less, will be better than one large one. Small bags of mosquito netting, lino, crinoline, or other porous material, should be provided, made in shape like a pillow-case, and open at one end; these may be from six to fifteen inches long. When small fishes, reptiles, or other specimens are procured in any locality, they may be placed indiscriminately in one or more of these bags (the mouths of which are to be tied up like a sack), and then thrown into the alcohol. Previously, however, a label of parchment, leather, or stout paper should be placed inside the bag, containing the name of the locality or other mark, and written in ordinary ink. The label, if dry before being placed in the bag, will retain its writing unchanged for a long time. The locality, or its number, should also be coarsely marked with a red pencil on the outside of the bag. In this way, the specimens, besides being readily identified, are preserved from rubbing against each other, and consequent injury. Still farther to facilitate this object, an India-rubber gas-bag may be employed to great advantage, by introducing it into the vessel, and inflating until all vacant space is filled up by the bag, and the consequent displacement of the spirit. When additional specimens are to be added, a portion of the air may be let out, and the bag afterwards again inflated. Should this arrangement be found impracticable, a quantity of tow, cotton or rags, kept over the specimens, will be found useful in preventing their friction against each other, or the sides of the vessel.

The larger snakes should be skinned, as indicated hereafter, and the skins thrown into alcohol. Much space will in this way be saved. Smaller specimens may be preserved entire, together with lizards, salamanders, and small frogs. All of these that can be caught should be secured and preserved. The head, the legs with the feet, the tail, in fact, the entire skin of turtles, may be preserved in alcohol; the soft parts then extracted from the shell, which is to be washed and dried.

Every stream, and indeed, when possible, many localities in each stream should be explored for fishes, which are to be preserved as directed. For these, as well as the other alcoholic collections, the lino bags are very useful.

Great attention should be paid to procuring many specimens of the different kinds of small fishes, usually known as minnows, shiners, chubs, &c. Among these will always be found the greatest variety of species, some never exceeding an inch in length. These fish are generally neglected, under the idea that they are merely the young of larger kinds; even if they should prove to be such, however, they will be none the less interesting. Different forms will be found in different localities. Thus the *Etheostomata* or Darters, and the *Cotti*, live under stones, or among gravel, in shallow clear streams, lying flat on the ground. Others will be dislodged by stirring under roots or shelving banks along the water's edge. The *Melanura*, or mud fish (a few inches in length), exist *in* the mud of ditches, and are secured by stirring up this mud into a thin paste with the feet, and then drawing a net through. The sticklebacks and cyprinodonts live along the edges of fresh and salt water. The *Zygonectes* swim in pairs slowly along the surface of the water, the tip of the nose generally exposed. They generally have a broad black stripe on the side. By a careful attention to these hints, many localities supposed to be deficient in species of fishes, will be found to yield a large number.

The alcohol used on a march may be supplied with tartar emetic. This, besides adding to its preservative power, will remove any temptation to drink it, on the part of unscrupulous persons.

Nearly all insects, scarcely excepting the *Lepidoptera*, can be readily preserved in alcohol. Crabs and small shells may likewise be treated in the same manner.

It is not usually possible to collect minerals, fossils, and geological specimens in very great mass while travelling. The fossils selected should be as perfect as possible; and especial care should be paid to procuring the bones and teeth of vertebrate animals. Of minerals and rocks, specimens as large as a hickory-nut will, in many cases, be sufficient for identification.

Where collections cannot be made in any region, it will be very desirable to procure lists of all the known species, giving the names by which they are generally recognized, as well as the scientific name, when this is practicable. The common names of specimens procured should also be carefully recorded.

All facts relating to the habits and peculiarities of the various species of animals should be carefully recorded in the note-book, especially those having relation to the peculiarities of the season of reproduction, &c. The accounts of hunters and others should also be collected, as much valuable information may thus be secured. The colors of the reptiles and fishes when alive should always be given, when practicable, or, still better, painted on a rough sketch of the object.

I.—LIST OF APPARATUS USEFUL FOR TRAVELLING PARTIES.

1. Two leather panniers, supplied with back strap for throwing across a mule. One of these is intended to contain the copper kettles, and their included alcohol, together with the nets and other apparatus; the other to hold the botanical apparatus, skins of animals, minerals, &c. These, when full, should not weigh more than one hundred and fifty pounds the pair.

2. Two copper kettles in one of the panniers, to contain the alcohol for such specimens as require this mode of preservation, viz.: reptiles, fishes, small quadrupeds, most insects, and all soft invertebrates. The alcohol, if over 80 per cent., should have one-fourth of water added.

3. An iron wrench to loosen the screw-caps of the copper kettles, when too tight to be managed by hand.

4. Two India-rubber bags, one for each kettle. These are intended to be inflated inside of the kettles, and by displacing the alcohol cause it to rise to the edge of the brass cap, and thus fill the kettle. Unless this is done, and any unoccupied space thus filled up, the specimens will be washed against the sides of the vessel, and much injured.

5. Small bags made of lino, mosquito-netting or cotton, of different sizes, and open at one end. These are intended, in the first place, to separate the specimens of different localities from each other; and, in the second place, to secure them from mutual friction or other injury. The number or name corresponding to the locality is to be marked on the outside with red chalk, or written with ink on a slip of parchment, and dropped inside. The specimens are then to be placed in the bag, a string tied round the open end, and the bag thrown into alcohol. The ink of the parchment must be dry before the slip is moistened in any way.

N. B. Fishes and reptiles over five or six inches in length should have a small incision made in the abdomen, to facilitate the introduction of the alcohol. Larger snakes and small quadrupeds may be skinned, and the skins placed in alcohol.

6. Red chalk pencils for marking the bags.

7. Parchment to serve as labels for the bags. This may also be cut up into labels, and fastened by strings to such specimens as are not suited for the bags. Leather, kid, buckskin, &c., will also answer this purpose.

8. Fishing-line and hooks.

9. Small seines for catching fishes in small streams. The two ends should be fastened to brails or sticks (hoe-handles answer well), which are taken in the hands of two persons, and the net drawn both up and down stream. Fishes may often be caught by stirring up the gravel or small stones in a stream, and drawing the net rapidly down the current. Bushes or holes

along the banks may be enclosed by the nets, and stirred so as to drive out the fishes, which usually lurk in such localities. These nets may be six or eight feet long.

10. Casting-net.

11. Alcohol. About five gallons to each travelling party. This should be about 80 per cent. in strength, and medicated by the addition of one ounce of tartar emetic to one gallon of alcohol, to prevent persons from drinking it.

12. Arsenic in two-pound tin canisters. This may be applied to the moist skins of birds and quadrupeds, either dry or mixed with alcohol.

13. Tartar emetic for medicating the alcohol as above.

14. Cotton or tow for stuffing out the heads of birds and mammals. To economize space, but little should be put into the bodies of the animals. The skulls of the quadrupeds had better be removed from the skins, but carefully preserved with a common mark.

15. Paper for wrapping up the skins of birds and small quadrupeds, each separately. The paper supplied for botanical purposes will answer for this.

16. Butcher-knife, scissors, needles and thread, for skinning and sewing up animals.

17. Blank labels of paper with strings attached for marking localities, sex, &c., and tying to the legs of the dried skins, or to the stems of plants.

18. Portfolio for collecting plants.

19. Press for drying plants between the blotting-paper. Pressure is applied by straps.

20. Very absorbent paper for drying plants.

21. Stiffer paper for collecting plants in the field. The same paper may be used for wrapping skins of birds and quadrupeds, as well as minerals and fossils.

22. Small bottles for collecting and preserving insects.

23. Geological hammer.

24. Double-barrelled gun and rifle.

25. Fine shot for small birds and mammals. Numbers 3, 6, and 9, are proper sizes: the latter should always be taken.

26. A pocket case of dissecting instruments will be very convenient.

27. Blowpipe apparatus for mineralogical examinations.

28. Pocket vial for insects.

29. Bottle of ether for killing insects.

30. Insect pins.

31. Cork-lined boxes.

II.—INSTRUMENTS, PRESERVATIVE MATERIALS, &c.

1. *Implements for Skinning.*—The implements generally required in skinning vertebrated animals are:—1. A sharp knife

or a scalpel. 2. A pair of sharp-pointed scissors, and one with strong short blades. 3. Needles and thread for sewing up the incisions in the skin. 4. A hook by which to suspend the carcass of the animal during the operation of skinning. To prepare the hook, take a string, of from one to three feet in length, and fasten one end of it to a stout fish-hook which has had the barb broken off. By means of a loop at the other end, the string may be suspended to a nail or awl, which, when the hook is inserted into the body of an animal, will give free use of both hands in the operation of skinning.

2. *Preservatives.*—The best material for the preservation of skins of animals consists of powdered arsenious acid, or the common arsenic of the shops. This may be used in two ways, either applied in dry powder to the moist skin, or else mixed with alcohol or water to the consistency of molasses, and put on with a brush. A little camphor may be added to the alcoholic solution. There are no satisfactory substitutes for arsenic; but, in its entire absence, corrosive sublimate, arsenic soap, camphor, alum, &c., may be employed.

The proper materials for stuffing out skins will depend much upon the size of the animal. For small birds and quadrupeds, cotton will be found most convenient; for the larger, tow. For those still larger, dry grass, straw, sawdust, bran, or other vegetable substances, may be used. Whatever substance be used, care must be taken to have it perfectly dry. Under no circumstances should animal matter, as hair, wool or feathers, be employed.

III.—SKINNING AND STUFFING.

Birds.—Whenever convenient, the following notes should be made previous to commencing the operation of skinning, as they will add much to the value of the specimens:—

1. The length, in inches, from tip of bill to the end of the tail; the distance between the two extremities of the outstretched wings; and the length of the wing from the carpal or wrist-joint. The numbers may be recorded as follows:—44, 66, 12 (as for a swan), without any explanation; it being well understood that the above measurements follow each other in a fixed succession. These numbers may be written on the back of the label attached to each specimen.

2. The color of the eyes, that of the feet, bill, gums, membranes, caruncles, &c.

3. The date, the locality, and the name of the collector.

4. The sex. All these points should be recorded on the label.

Immediately after a bird is killed, the holes made by the shot, together with the mouth and internal or posterior nostrils, should be plugged up with cotton, to prevent the escape of blood

and the juices of the stomach. A long narrow paper cone should be made; the bird, if small enough, thrust in, head foremost, and the open end folded down, taking care not to break or bend the tail feathers in the operation.*

When ready to proceed to skinning, remove the old cotton from the throat, mouth, and nostrils, and replace it by fresh. Then take the dimensions from the point of the bill to the end of the tail, from the tip of one wing to that of the other, when both are extended; and from the tip of the wing to the first or carpal-joint, as already indicated.

This being done, make an incision through the skin only, from the lower end of the breast-bone to the anus. Should the intestines protrude in small specimens, they had better be extracted, great care being taken not to soil the feathers. Now proceed carefully to separate the skin on each side from the subjacent parts, until you reach the knee, and expose the thigh; when, taking the leg in one hand, push or thrust the knee up on the abdomen, and loosen the skin around it until you can place the scissors or knife underneath, and separate the joint with the accompanying muscles. Place a little cotton between the skin and body to prevent adhesion. Loosen the skin about the base of the tail, and cut through the vertebræ at the last joint, taking care not to sever the basis of the quills. Suspend the body by inserting the hook into the lower part of the back or rump, and invert the skin, loosening it carefully from the body. On reaching the wings, which had better be relaxed previously by stretching and pulling, loosen the skin from around the first bone, and cut through the middle of it, or, if the bird be small enough, separate it from the next at the elbow. Continue the inversion of the skin by drawing it over the neck, until the skull is exposed. Arrived at this point detach the delicate membrane of the ear from its cavity in the skull, if possible, without cutting or tearing it; then, by means of the thumb-nails, loosen the adhesion of the skin to the other parts of the head, until you come to the very base of the mandibles, taking care to cut through the white nictitating membrane of the eye, when exposed, without lacerating the ball. Scoop out the eyes, and, by making one cut on each side of the head, through the small bone connecting the base of the lower jaw with the skull, another through the roof of the mouth at the base of the upper mandible, and between the jaws of the lower, and a fourth through the skull behind the orbits, and parallel to the roof of the mouth, you will have freed the skull from all the accompanying brain and muscle. Should anything still adhere, it may be removed separately. In making the first two cuts, care must be taken not to injure or sever the

* Crumpled or bent feathers may have much of their elasticity and original shape restored by dipping in hot water.

zygoma, a small bone extending from the base of the upper mandible to the base of the lower jaw-bone. Clean off every particle of muscle and fat from the head and neck, and applying the preservative abundantly to the skull, inside and out, as well as to the skin, restore these parts to their natural position. In all e preceding operations, the skin should be handled as near the point of adhesion as possible, especial care being taken not to stretch it.

Finely powdered plaster of Paris, chalk, or whiting, may be used to great advantage by sprinkling on the exposed surface of the carcass, and inside of the skin, to absorb the grease and blood.

The next operation is to connect the two wings inside of the skin by means of a string, which should be passed between the lower ends of the two bones forming the forearm, previously, however, cutting off the stump of the arm, if still adhering at the elbow. Tie the two ends of the strings so that the wings shall be kept at the same distance apart as when attached to the body. Skin the leg down to the scaly part, or tarsus, and remove all the muscle. Apply the arsenic to the bone and skin, and, wrapping cotton round the bone, pull it back to its place. Remove all the muscle and fat which may adhere to the base of the tail or the skin, and put on plenty of the preservative wherever this can be done. Lift up the wing, and remove the muscle from the forearm by making an incision along it, or, in many cases, the two joints may be exposed by carefully slipping down the skin towards the wrist-joint, the adhesion of the quills to the bone being loosened.

The bird is now to be restored to something like its natural shape by means of a filling of cotton or tow. Begin by opening the mouth and putting cotton into the orbits and upper part of the throat, until these parts have their natural shape. Next take tow or cotton, and after making a roll rather less in thickness than the original neck, put it into the skin, and push firmly into the base of the skull. By means of this you can reduce or contract the neck if too much stretched. Fill the body with cotton, not quite to its original dimensions, and sew up the incision in the skin, commencing at the upper end, and passing the needle from the inside outwards; tie the legs and mandibles together, adjust the feathers, and, after preparing a cylinder of paper the size of the bird, push the skin into it so as to bind the wings closely to the sides. The cotton may be put in loosely, or a body the size of the original made by wrapping with threads. If the bird have long legs and neck, these had better be folded down over the body, and allowed to dry in that position. Economy in space is a great object in keeping skins; and such birds as herons, geese, swans, &c., occupy too much room when outstretched.

In some instances, as among the ducks, wood-peckers, &c., the head is so large that the skin of the neck cannot be drawn over it. In such cases, skin the neck down to the base of the

skull, and cut it off there. Then draw the head out again, and, making an incision on the outside, down the back of the skull, skin the head. Be careful not to make too long a cut, and to sew up the incision again.

The sex of the specimen may be ascertained after skinning, by making an incision in the inside near the vertebræ, and exposing the inside surface of the "small of the back." The generative organs will be found tightly bound to this region (nearly opposite to the last ribs, and separating it from the intestines. The testicles of the male will be observed as two spheroidal or ellipsoidal whitish bodies, varying with the season and species, from the size of a pin's head to that of a hazel-nut. The ovaries of the female, consisting of a flattened mass of spheres, variable in size with the season, will be found in the same region.

For transportation, each skin of mammals, as well as of birds, should, when possible, be wrapped in paper.

2. *Mammals.*—The mode of preparing mammals is precisely the same as for birds, in all its general features. Care should be taken not to make too large an incision along the abdomen. The principal difficulty will be experienced in skinning the tail. To effect this, pass the slipknot of a piece of strong twine over the severed end of the tail, and, fastening the vertebræ firmly to some support, pull the twine towards the tip until the skin is forced off. Should the animal be large and an abundance of preservative not at hand, the skin had better remain inverted. In all cases it should be thoroughly and rapidly dried.

The tails of some mammalia cannot be skinned as directed above. This is particularly the case with beavers, opossums, and those species which use their tail for prehension or locomotion. Here the tail is usually supplied with numerous tendinous muscles, which require it to be skinned by making a cut along the lower surface or right side, nearly from one end to the other, and removing the bone and flesh. It should then be sewed up again, after a previous stuffing.

For the continued preservation of hair or fur of animals against the attacks of moths and other destructive insects, it will be necessary to soak the skins in a solution of corrosive sublimate in alcohol or whiskey, allowing them to remain from one day to several weeks, according to the size. After removal the hair must be thoroughly washed or rinsed in clean water, to remove as much as possible of the sublimate; otherwise, exposure to light will bleach all the colors.

Finely powdered green vitriol, or copperas sprinkled on either hair or feathers, will have an excellent effect in keeping out moths. Covering with tobacco leaves will also answer the same end.

In some instances large skins may be preserved by being salted down in casks.

3. *Reptiles.*—The larger *lizards*, such as those exceeding twelve or eighteen inches in length, may be skinned according to the principles above mentioned, although preservation in spirit, when possible, is preferable for all reptiles.

Large *frogs* and *salamanders* may likewise be skinned, although cases where this will be advisable are very rare.

Turtles and *large snakes* will require this operation.

To one accustomed to the skinning of birds, the skinning of frogs or other reptiles will present no difficulties.

The skinning of a snake is still easier. Open the mouth and separate the skull from the vertebral column, detaching all surrounding muscles adherent to the skin. Next, tie a string around the stump of the neck, and, holding on by this, strip the skin down to the extremity of the tail The skin thus inverted should be restored to its proper state, and then put in spirit or stuffed, as convenient. Skins of reptiles may be stuffed with either sand or sawdust, by the use of which their shape is more easily restored.

Turtles and tortoises are more difficult to prepare in this way, although their skinning can be done quite rapidly. "The breast-plate must be separated by a knife or saw from the back; and, when the viscera and fleshy parts have been removed, restored to its position. The skin of the head and neck must be turned inside out, as far as the head, and the vertebræ and flesh of the neck should be detached from the head, which, after being freed from the flesh, the brain and the tongue, may be preserved with the skin of the neck. In skinning the legs and the tail, the skin must be turned inside out, and, the flesh having been removed from the bones, they are to be returned to their places by re-drawing the skin over them, first winding a little cotton or tow round the bones to prevent the skin adhering to them when it dries."—RICHARD OWEN.

Another way of preparing these reptiles is as follows:—Make two incisions, one from the anterior end of the breast-plate to the symphysis of the lower jaw, and another from the posterior end of the breast-plate to the vent or tip of the tail; skin off these regions, and remove all fleshy parts and viscera without touching the breast-plate itself. Apply preservative, stuff, and sew up again both incisions.

"When turtles, tortoises, crocodiles, or alligators, are too large to be preserved whole in liquor, some parts, as the head, the whole viscera stripped down from the neck to the vent, and the cloaca, should be put into spirit or solution."—R. OWEN.

4.—*Fishes.*—As a general rule, fishes, when not too large, are best preserved entire in spirits.

Nevertheless, they may be usefully skinned and form collections, the value of which is not generally appreciated. In many cases, too, when spirit or solutions cannot be procured, a fish may be preserved which would otherwise be lost.

There are two modes of taking the skin of a fish—1. The whole animal can be skinned and stuffed like a bird, mammal or reptile. 2. One-half of the fish can be skinned, and, nevertheless, its natural form preserved.

Sharks, *skates*, *sturgeons*, *garpikes* or *garfishes*, *mudfishes*, and all those belonging to the natural orders of *Placoids* and *Ganoids*, should undergo the same process as given above for birds, mammals, and reptiles. An incision should be made along the right side, the left always remaining intact, or along the belly. The skin is next removed from the flesh, the fins cut at their bases under the skin, and the latter inverted until the base of the skull is exposed. The inner cavity of the head should be cleaned, an application of preservative made, and the whole, after being stuffed in the ordinary way, sewed up again. Fins may be expanded when wet, on a piece of stiff paper, which will keep them sufficiently stretched for the purpose. A varnish may be passed over the whole body and fins, to preserve somewhat the color.

In the case of *Ctenoids*, perches, and allied genera; and *Cycloids*, trouts, suckers, and allied genera; one-half of the fish may be skinned and preserved. To effect this, lay the fish on a table with the left side up; the one it is intended to preserve. Spread out the fins by putting underneath each a piece of paper, to which it will adhere on drying. When the fins are dried, turn the fish over, cut with scissors or a knife all around the body, a little within the dorsal and ventral lines, from the upper and posterior part of the head, along the back to the tail, across the base of the caudal fin down, and thence along the belly to the lower part of the head again. The dorsal, caudal, and anal fins, cut below their articulations. This done, separate the whole of the body from the left side of the skin, commencing at the tail. When near the head, cut off the body with the right ventral and pectoral fins, and proceed by making a section of the head and removing nearly the half of it. Clean the inside, and pull out the left eye, leaving only the cornea and pupil. Cut a circular piece of black paper of the size of the orbit, and place it close to the pupil. Apply the preservative, fill the head with cotton as well as the body. Turn over the skin and fix it on a board prepared for that purpose. Pin or tack it down at the base of the fins. Have several narrow bands of paper to place across the body, in order to give it a natural form, and let it dry. The skins may be taken off the board or remain fixed to it, when sent to their destination, where they should be placed on suitable boards of proper size, for permanent preservation.

Such a collection of well-prepared fishes will be useful to the practical naturalist, and illustrate, in a more complete manner, to the public the diversified forms and characters of the class of fishes which specimens preserved in alcohol do not so readily show.

These skins may also be preserved in alcohol.

IV.—PRESERVING IN LIQUIDS, AND BY OTHER MODES BESIDES SKINNING.

1.—*General Remarks.*—The best material for preserving animals of moderate size is alcohol. When spirits cannot be obtained, the following substitutes may be used:—

I. *Goadby's Solution.*—A. *The aluminous fluid*, composed of rock salt, 4 ounces; alum, 2 ounces; corrosive sublimate, 4 grains; boiling water, 2 quarts. B. *The saline solution*, composed of rock salt, 8 ounces; corrosive sublimate, 2 grains; boiling water, 1 quart. To be well stirred, strained and cooled.

II. A strong brine, to be used as hereafter indicated for Goadby's solution.

III. In extreme cases, dry salt may be used, and the specimens salted down like herring, &c.

The alcohol, when of the ordinary strength, may be diluted with one-fifth of water, unless it is necessary to crowd the specimens very much. The fourth proof whiskey of the distillery, or the high wines, constituting an alcohol of about 60 per cent., will be found best suited for collections made at permanent stations and for the museum. Lower proofs of rum or whiskey will also answer, but the specimen must not be crowded at all.

To use Goadby's solution, the animal should first be macerated for a few hours in fresh water, to which about half its volume of the concentrated solution may then be added. After soaking thus for some days, the specimens may be transferred to fresh concentrated solution. When the aluminous fluid is used to preserve vertebrate animals, these should not remain in it for more than a few days; after this they are to be soaked in fresh water and transferred to the saline solution. An immersion of some weeks in the aluminous fluid will cause a destruction of the bones. Specimens must be kept submerged in these fluids. The success of the operation will depend very much upon the use of a weak solution in the first instance, and a change to the saturated fluid by one or two intermediate steps.

The collector should have a small keg, jar, tin box, or other suitable vessel, partially filled with liquor, into which specimens may be thrown (alive if possible) as collected. The entrance of the spirit into the cavities of the bodies should be facilitated by opening the mouth, making a small incision in the abdomen a half or one inch long, or by injecting the liquor into the intestines through the anus, by means of a small syringe. After the animal has soaked for some weeks in this liquor, it should be transferred to fresh. Care should be taken not to crowd the specimens too much. When it is impossible to transfer specimens to fresh spirits from time to time, the strongest alcohol should be originally used.

To pack the specimens for transportation, procure a small keg, which has been properly swelled, by allowing water to stand

in it for a day or two, and from this extract the head by knocking off the upper hoops. Great care must be taken to make such marks on the hoops and head, as will assist in their being replaced in precisely the same relative position to each other and the keg that they originally held. At the bottom of the keg place a layer of tow or rags, moistened in liquor, then one of specimens, then another of tow and another of specimens; and so on alternately until the keg is *entirely filled*, exclusive of the spirit. Replace the head, drive down the hoops, and fill completely with spirits by pouring through the bung-hole. Allow it to stand at least half an hour, and then supplying the deficiency of the liquor, insert the bung and fasten it securely. An oyster can or other tin vessel may be used to great advantage, in which case the aperture should be soldered up and the vessel enclosed in a box. A glass jar or bottle may also be employed, but there is always a risk of breaking and leaking. In the absence of tow or rags, chopped straw, fine shavings, or dry grass, may be substituted.

It will conduce greatly to the perfect preservation of the specimens, during transportation, if each one is wrapped up in cotton cloth, or even paper. A number of smaller specimens may be rolled successively in the same wrapper. In this way friction, and the consequent destruction of scales, fins, &c., will be prevented almost entirely. The travelling bags described on p. 156, will answer the same purpose.

Should the specimens to be packed vary in size, the largest should be placed at the bottom. If the disproportion be very great, the delicate objects at the top must be separated from those below, by means of some immovable partition, which, in the event of the vessel being inverted, will prevent crushing. The most imperative rule, however, in packing, is to have the vessel perfectly full, any vacancy exposing the whole to the risk of loss.

It is sometimes necessary to guard against the theft of the spirit employed, by individuals who will not be deterred from drinking it by the presence of reptiles, &c. This may be done by adding a small quantity of tartar emetic, ipecacuanha, quassia, or some other disagreeable substance. The addition of corrosive sublimate will add to the preservative power of the spirit.

2.—*Vertebrata.*—Fishes under five or six inches in length need not have the abdominal incision. Specimens with the scales and fins perfect should be selected, and, if convenient, stitched, pinned, or wrapped in bits of muslin, &c., to preserve the scales. In general, fishes under twelve or fifteen inches in length, should be chosen. The skins of larger ones may be put in liquor. It is important to collect even the smallest. The same principles apply to the other vertebrata.

The smallest and most delicate specimens may be placed in bottles or vials, and packed in the larger vessels with the other specimens.

3.—*Invertebrata.—Insects, Bugs, &c.*—The harder kinds may be put in liquor, as above, but the vessel or bottle should not be very large. Butterflies, wasps, flies, &c., may be pinned in boxes, or packed in layers with soft paper or cotton. Minute species should be carefully sought under stones, bark, dung, or flowers, or swept with a small net from grass or leaves. They may be put in quills, small cones of paper, or in glass vials. They can be readily killed by immersing the bottles, &c., in which they are collected, in hot water, or exposing them to the vapor of ether.

When possible, a number of ounce or two ounce vials, with very wide mouths, well stopped with corks, should be procured, in which to place the more delicate invertebrata, as small crustacea, worms, mollusca, &c.

It will frequently be found convenient to preserve or transport insects pinned down in boxes. The bottoms of these are best lined with cork or soft wood.

The traveller will find it very convenient to carry about him a vial having a broad mouth, closed by a tight cork. In this should be contained a piece of camphor, or, still better, of sponge soaked in ether, to kill the insects collected. From this the specimens should be transferred to other bottles. They may, if not hairy, be killed by immersing directly in alcohol.

The camphor should always be fixed in the box containing insects, as it would break the feet and antennæ of the latter if in a loose and crystalline state. It may be kept in a piece of muslin or canvas, and then pinned at the bottom of the box.

Sea-urchins and starfishes may also be dried, after having been previously immersed for a minute or two in boiling water, and packed up in cotton, or any soft material which may be at hand.

The hard parts of coral, and shells of mollusca may also be preserved in a dried state. The soft parts are removed by immersing the animals for a minute or two in hot water, and washing clean afterwards. The valves of bivalve shells should be brought together by a string.

Wingless insects, such as spiders, scorpions, centipedes or thousand-legs, earth-worms, hair-worms, and generally all worm-like animals found in the water, should be preserved in alcoholic liquor, and in small bottles or vials.

V.—EMBRYOS.

Much of the future progress of zoölogy will depend upon the extent and variety of the collections which may be made of the embryos and fœtuses of animals. No opportunity should be omitted to procure these and preserve them in spirits. All stages of development are equally interesting, and complete series for the same species would be of the highest importance. Whenever any female mammal is killed, the uterus should be examined for embryos. When eggs of birds, reptiles, or fish are

emptied of their young, these should be preserved. It will be sufficiently evident that great care is required to label the specimens, as in most cases it will be impossible to determine the species from the zoölogical characters.

VI.—NESTS AND EGGS.

Nothing forms a more attractive feature in a museum, or is more acceptable to amateurs, than the nests and eggs of birds. These should be collected whenever they are met with, and in any amount procurable for each species, as they are always in demand for purposes of exchange. Hundreds of eggs of *any* species with their nests (or without, when not to be had) will be gladly received.

Nests require little preparation beyond packing, so as to be secure from crumbling or injury. The eggs of each nest, when emptied, may be replaced in it and the remaining space filled with cotton.

Eggs, when fresh, and before the chick has formed, may be emptied by making a small pin-hole at each end, and blowing or sucking out the contents. Should hatching have already commenced, an aperture may be made in one side by carefully pricking with a fine needle round a small circle or ellipse, and thus cutting out a piece. The larger kinds should be well washed inside, and all allowed to dry before packing away. If the egg be too small for the name, a number should be marked with ink corresponding to a memorandum list. Little precaution is required in packing, beyond arranging in layers with cotton, and having the box entirely filled.

The eggs of reptiles, provided with a calcareous shell, can be prepared in a similar way.

The eggs of fishes, salamanders, and frogs may be preserved in spirits, and kept in small vials or bottles. A label should never be omitted.

VII.—SKELETONIZING.

Skulls of animals may be prepared by boiling in water for a few hours. A little potash or lye added, will facilitate the removal of the flesh.

Skeletons may be roughly prepared by skinning the animal and removing all the viscera, together with as much of the flesh as possible. The bones should then be exposed to the sun or air until completely dried. Previously, however, the brain of large animals should be removed by separating the skull from the spine, and extracting the contents through the large hole in the back of the head. In case it becomes necessary to disjoint a skeleton, care should be taken to attach a common mark to all the pieces, especially when more than one individual is packed in the same box.

Skulls and skeletons may frequently be picked up, already cleaned by other animals or exposure to weather. By placing small animals near an ant's nest, or in water occupied by tadpoles, or small crustacea, very beautiful skeletons may often be obtained. The sea-beach sometimes affords rich treasures in the remains of porpoises, whales, large fishes, as sharks, and other aquatic species.

VIII.—PLANTS.

The collector of plants requires but little apparatus; a few quires or reams of unsized paper, of folio size, will furnish all that will be needed. The specimens, as gathered, may be placed in a tin box, or still better, in a portfolio of paper, until reaching home. About forty or fifty sheets of the paper should be put into the portfolio on setting out on an excursion. Put the specimens of each species in a separate sheet as fast as gathered from the plant, taking a fresh sheet for each additional species. On returning to camp, place these sheets (without changing or disturbing the plants) between the absorbent drying papers in the press, and draw the straps tight enough to produce the requisite pressure. The next day the driers may be changed, and those previously used laid in the sun to dry; this to be continued until the plants are perfectly dry. If paper and opportunities of transportation be limited, several specimens from the same locality may be combined in the same sheet after they are dry.

Place in each sheet a slip of paper having a number or name of locality written on it corresponding with a list kept in a memorandum book. Record the day of the month, locality, size, and character of the plant, color of flower, fruit, &c.

If the stem is too long, double it or cut in into lengths. Collect, if possible, half a dozen specimens of each kind. In the small specimens, collect the entire plant, so as to show the root.

In many instances old newspapers will be found to answer a good purpose both in drying and in keeping plants, although the unprinted paper is best—the more porous and absorbent the better.

When not travelling, pressure may be most conveniently applied to plants by placing them between two boards, with a weight of about 50lbs. laid on the top.

While on a march, the following directions for collecting plants, drawn up by Major Rich, are recommended:—

Have thick cartridge or envelope-paper, folded in *quarto* form, and kept close and even by binding with strong cord; newspapers will answer, but are liable to chafe and wear out; a few are very convenient to mix in with the hard paper as dryers. This herbarium may be rolled up in the blanket while travelling, and placed on a pack-animal. The specimens collected along the road may be kept in the crown of the hat when

without a collecting-box, and placed in paper at noon or at night. Great care should be taken to keep the papers dry and free from mould. When there is not time at noon to dry the papers in the sun, they should be dried at night by the fire, when, also, the dried specimens are placed at the bottom of the bundle, making room on top for the next day's collection. A tin collecting-box is very necessary; plants may be preserved for two or three days in one, if kept damp and cool. It is also convenient in collecting *land-shells*, which is generally considered part of a botanist's duty. A collector should also always be provided with plenty of ready made seed-papers, not only for preserving seeds, but mosses and minute plants. Many seeds and fruits cannot be put in the herbarium, particularly if of a succulent nature, causing mouldiness, and others form irregularities and inequalities in the papers, thus breaking specimens and causing small ones and seeds to drop out. Fruits of this kind should be numbered to correspond with the specimen, and kept in the saddle-bag or some such place. It is necessary, in order to make good specimens, to avoid heavy pressure and keep the papers well dried; otherwise they get mouldy, turn black, or decay.

The seeds and fruits of plants should be procured whenever practicable, and slowly dried. These will often serve to reproduce a species, otherwise not transportable or capable of preservation.

On board ship, it is all-important to keep the collections from getting wet with salt water. The papers can generally be dried at the galley. The whole herbarium should be exposed to the sun as often as possible, and frequently examined, and the mould brushed off with a feather or camel-hair pencil.

In collecting algæ, corallines, or the branched, horny, or calcareous corals, care should be taken to bring away the entire specimen with its base or root. The coarser kinds may be dried in the air (but not exposed to too powerful a sun), turning them from time to time. These should not be washed in fresh water, if to be sent any distance. The more delicate species should be brought home in salt water, and washed carefully in fresh, then transferred to a shallow basin of clean fresh water, and floated out. A piece of white paper of proper size is then slipped underneath, and raised gently out of the water with the specimen on its upper surface. After finally adjusting the branches with a sharp point or brush, the different sheets of specimens are to be arranged between blotters of bibulous paper and cotton cloth, and subjected to gentle pressure. These blotters must be frequently changed till the specimens are dry.

IX.—MINERALS AND FOSSILS.

The collections in mineralogy and palæontology are, amongst all, those which are most easily made; whilst, on the other hand,

their weight, especially when on a march, will prevent their being gathered on an extensive scale.

All the preparation usually needed for preserving minerals and fossils consists in wrapping the specimens separately in paper, with a label inside for the locality, and packing so as to prevent rubbing. Crumbling fossils may be soaked to advantage in a solution of glue.

Fossils of all kinds should be collected. Minerals and samples of rocks are also desirable. The latter should be properly selected, and cut to five by three inches of surface and one to two inches thick.

The vertebrate fossils of North America are of the highest interest to naturalists. These are found in great abundance in those portions known as "Mauvaises Terres," or "Bad Lands," and occurring along the Missouri and its tributaries, White River, Milk River, Platte, Eau qui Court, &c. The banks and beds of these and other streams likewise, contain rich treasures of fossil bones. Similar remains are to be looked for in all caves, peat bogs, alluvial soil, marl-pits, fissures in rocks, and other localities throughout North America.

The floor of any cavern, if dug up and carefully examined, will generally be found to contain teeth, bones, &c. These, however similar in appearance to recent or domesticated species, should be carefully preserved.

Specimens ought to be tightly packed up in boxes, taking care that each one is wrapped up separately, in order that the angles or crystalline surfaces should not be destroyed by transportation; their value depending upon their good condition. The same precautions will be required for corals. The interstices between the specimens, in the box or cask, may be occupied by sawdust, sand, shavings, hay, cotton, or other soft substance. It is absolutely essential that no cavity be left in the vessel or box.

X.—MINUTE MICROSCOPIC ORGANISMS.

It is very desirable to procure specimens, from many localities, of the various forms of microscopic animals and plants, not only on account of their intrinsic interest, but for their relation to important general questions in physical and natural science. These will almost always be found to occur in the following localities:

1. In all light-colored clays or earths, as found in peat bogs, meadows, soils, &c., particularly when these are remarkably light.

2. In the mud from the bottom of lakes and pools. A small handful of this mud or of the confervoid vegetation on the bottom, if dried *without squeezing*, will retain the Diatomaceæ and Desmidieæ.

3. In the mud (dried) from the bottom and along the margins

of streams in any locality. The muds from brackish and from fresh waters will differ in their contents.

4. In soil from the banks of streams. The surface and subsoils should both be collected.

5. In the soundings brought up from the bottom of the sea or lakes. These should be collected from the greatest possible depths. If an armature be used to the lead, it should be of soap rather than fatty matter, as being more readily removed from the organisms. The mud which adheres to anchors, to rocks, &c., below *high*-water mark, as well as below *low* water, should also be carefully gathered.

6. In bunches of damp moss from rocks, roofs of houses, trees, about pumps, &c.

7. In the deposits in the gutters and spouting of roofs of houses.

8. In the dust which at sea collects upon the sails or deck of vessels. When not of sufficient quantity to be scraped off, enough may be obtained for examination by rubbing a piece of soft clean paper over the surface affected.

Specimens of all these substances should be gathered, and, when moist, dried *without squeezing.* The quantity may vary from a few grains to an ounce, depending on the mode of transportation to be adopted. *Every specimen, as collected, should have the date, locality, depth below the surface, collector, &c., marked immediately upon the envelope.*

It is also very important to collect filterings from river, brackish, and sea-waters. To do this, take a circular piece of fine chemical filtering paper,* six inches or thereabouts in diameter (the patent blotting-paper will answer if the other cannot be procured), and weigh it carefully in a delicate balance. Pass a quantity of the water, varying with its turbidity, from a pint to a gill, through the paper, and allow this to dry. Mark the paper or its envelope with the original weight of the paper, the amount of water passed through, date, place, &c. It is desirable to have specimens thus prepared for every locality, and for every month in the year. They may be sent, as well as light packages of dried muds, &c., by mail, and should be transmitted as speedily as possible.

When the water of lakes and ponds has been rendered turbid by minute green or brown specks, these should be gathered by filtration through paper or rag, which may then be dried, or, still better, have this matter scraped off into a small vial of alcohol.

* The Smithsonian Institution will furnish filtering-paper to those who may wish it.

ART. VI.—RIDGWAY FARM & LAND CO'S, PROPERTY—GEOLOGICAL REPORT.—By DR. CHARLES T. JACKSON.

CHAS. K. LANDIS, ESQ.—*Dear Sir:* During the past month, I have at your request examined the geological character and resources of the Ridgway Farm and Land Company's property in Elk County, Pennsylvania, and have now the honor of presenting to you my report.

The tract of land in question comprises some twenty-seven thousand acres, and is eligibly situated, having a temperate climate, and being perfectly healthy.

The latitude of the village of St. Mary's is 41° 25′ North, and its longitude is 1° 40′ West of the City of Washington. Its elevation above the Sea is about 1,600 feet, as near as can be estimated from the range of the barometer.

It is about one hundred miles east of Lake Erie, and the track of the Sunbury and Erie Railroad to the city of Erie is about one hundred and ten miles.

The country is not mountainous, but is gently undulating, none of the hills being too steep or high to interfere with easy culture. The forest land is most heavily timbered with gigantic hemlock, curly maple, bass, beach, ash, black birch, chestnut, oak, pine, and cherry trees, which by their thrifty condition amply prove the luxuriance of the soil.

Some of the chestnut trees measured by me were 13½ and 16½ feet in circumference, and some of the pines were 13 feet 2 inches in circumference, and 137 feet high; an ash tree measured 10 feet 3 inches in circumference, and the hemlocks average at least 8 feet around the butt. The maple and cherry trees are from 6 to 8 feet in circumference, and are very sound and perfect. At the saw mills I measured many white pine logs that were from 3 feet to 3 feet 11 inches in diameter, and the cherry logs were from 2 feet to 2½ feet in diameter, and very clear from knots, as was evident on inspection of the sawed boards.

The hemlock logs were from 3 to 4 feet in diameter, and those of bass wood generally were 3 feet, and the ash were from 2½ to 3 feet, and those of curly maple 3 feet at the butt.

By this examination of the timber actually at the saw mills, some idea may be formed of the workable lumber cut and brought out from the contiguous forests. It appears that the forest timber is not only unusually large, but it is also remarkably sound and very clear from knots. The trees generally on the Company's land run remarkably high before throwing out branches, so that it is not uncommon to find clean trunks 80 or more feet in length.

The best soil appears to be indicated by the great abundance of maple, black birch and ash trees, which abound in the northern portions of the forest land; but little of this has been cleared

and cultivated. Owing to the abundance of hemlock trees near St. Mary's, it has been thought that large Tanneries might be advantageously established in that town, and I have no doubt of the feasibility of this project, which will follow quickly after the completion of the Sunbury and Erie Railroad, which will establish a ready communication with the markets, and allow the hides to be carried to the tanneries at little cost. It is always advisable to carry the hides to the tan bark, since they are of much less bulk and weight than the bark itself. The moment an adequate market is afforded by the completion of the above mentioned Railroad a large income will be derived from the tan bark, as it is of an excellent quality, and abounds in great quantities. The character of the soil of this region of country, as proved not only by its geology, but also by practical experiments, is well adapted to the growth of the cereal grains and grasses; rye, oats, barley and wheat thrive very well, but rye and oats, I observed, were most extensively cultivated and were very thrifty. The last winter having been one of unusual severity, had injured the crop of Winter wheat considerably, so that the crops did not appear to stand even and regularly in the fields; but I was informed by the farmers that their wheat was very rarely winter-killed or thrown out by the frost. From some cause not learned by me, corn was not extensively raised at St. Mary's. I suppose that the small grains are preferred by the people, who are nearly all Germans, and have been only a few years in this country. If there is any difficulty in the ripening of corn, this may be easily remedied by the selection of early northern varieties, such as are cultivated in Massachusetts and New Hamsphire. From the samples I noticed at the grist mills, I saw that the last year's corn was not thoroughly ripened, and that it was a Southern variety, and not adapted to the climate of this district.

As a grazing country, nothing can surpass the Company's lands; for clover, herdsgrass and red-top thrive in the most luxuriant manner, and yield heavy crops of the best kinds of hay, and furnish the richest pastures. Cattle will be raised in large numbers when the Railway shall open a ready market for beef, and large profits will be derived, especially from the raising of sheep. All our usual garden vegetables grow luxuriantly in St. Mary's, and the kitchen-gardens bear testimony not only to the goodness of the soil, but also to the skill of the German women, who generally take the entire care of them; and while they raise esculents for the table, do not forget to cultivate also an abundance of beautiful flowers, with which to decorate their parlors. The uniform testimony of all the farmers of St. Mary's, I found to be in favor of the goodness of the soil.

The soil is a good mellow loam, sufficiently retentive of manures and of moisture, without being clayey or stony. Its geological origin is from sandstone, limestone, shales, and fire clays of

the coal formation, materials well known to produce good soils when sufficiently supplied with mould, as is the case in the Company's lands. Judging from the state of the crops at the time of my visit, and from the blooming of wild wood flowers, I should regard the climate as like that of Connecticut and Massachusetts, the elevation of the land being nearly equivalent to a degree of latitude toward the North for temperature.

The population of St. Mary's alone now numbers about 2,500 persons. They are mostly Germans, except those who have recently settled, and who are becoming quite numerous; they are usually farmers from Pennsylvania, New York, New Jersey, and New England. The inhabitants appear to be a happy and contended people, having no political or religious dissensions among themselves.

GEOLOGICAL RESOURCES.

The lands of the Ridgway Farm and Land Company are all in the carboniferous group, and contain the usual rocks of the bituminous coal field, namely: gray sandstones, shales, limestones, and fire clay, with regular beds of good bituminous coal. These strata are nearly horizontal, not in any case dipping more than five degrees from the horizon, and generally between two and three degrees.

The sandstone forms a good building material, and will serve for the construction of Iron Furnaces, which will be lined with bricks made of the fire-clay, which is found beneath each bed of coal.

The limestone will serve not only for building mortar and agriculture, but also for fluxing the iron ores in the process of smelting iron. The fire-clay will serve for making fire-proof bricks, both for home use and for exportation, of which a large business is already carried on in the adjoining county of Clinton. Iron Ores, namely: carbonate of iron, in large balls and masses, and brown hematite occur, with the shales and fire-clays of the coal strata, and may be obtained in adequate quantities for supplying blast furnaces, which will be erected when the coal mines shall have gone into operation.

Numerous beds of excellent bituminous coal, with a stratum of slaty cannel over them, occur in very convenient locations for ready mining, and will be most extensively wrought when the western division of the Sunbury and Erie Railroad is finished, so as to open a direct communication between St. Mary's and Lake Erie; this division is now in active process of completion. An immense trade in coal and iron will spring up in this district in the course of a few years, and a great portion of the large demand for the lake navigation will be chiefly supplied from the Company's lands, for there is no other conveniently situated place, where a large supply of coals can be obtained so accessible by means of Railways.

At the present time I learn that the demand for coals upon the great lakes is far beyond the supply that can now be obtained, and this demand is rapidly increasing, owing to the augmentation of steam navigation on the lakes. Furnaces for smelting iron and other ores, and numerous founderies will spring up on the lake shore, when an adequate supply of good coals can be obtained at reasonable cost.

Few of our citizens upon the coast realize the extent and importance of the trade upon the great lakes, and many will be surprised to learn that the tonnage of the lakes considerably exceeds that of the sea-coast of the United States; but such is undeniably the case. Steam navigation is destined to increase on the lakes in a far greater ratio, and the Canadas will not fail to avail themselves of the coals from the great bituminous coal-fields of western Pennsylvania.

It will be seen by the results of my chemical analyses of the coals, that they are admirably adapted for the making of illuminating gas, and also for steamboat and furnace uses, besides being excellent for warming houses, and for all uses to which the best bituminous coals are applied.

The slaty cannel coals will serve for the manufacture of the bituminous oil which has lately come into use for illumination, and for oiling machinery. The cannel coal will also serve for making gas, but its coke is not so valuable as that from other coals, on account of the larger proportion of ashes it yields when burned. The coals from the principal beds make excellent coke, quite compact and suitable for use in smelting furnaces, for reduction of iron from the ores, and also for founderies where iron is to be melted and cast.

From the observations I have made, I am of opinion that there are at least *six beds of coal* in the Company's lands, and but few of the upper ones only have suffered any considerable loss by denudation, or washing away by the formation of runs and valleys of excavation by the action of water.

It is impossible without sinking a shaft, or boring through the strata, to establish the order of position of the several beds with certainty; since the openings now made are too limited to admit of accuracy in determination of their dip or inclination by which their positions could be made known when the levels of the different points were also measured.

Allowing that there are but two workable beds of coal, one four, and the other six feet in thickness, and that for every foot of thickness of a coal bed, 1,000 tons of coal is to be estimated per acre, (the admitted rule,) then there will be no less than 10,000 tons of coal in each acre of land underlaid by these two beds.

In many locations in the Company's lands, there are two four-feet beds, and one of six feet in thickness.

I do not estimate any bed less than three feet in thickness as a workable bed, though I am aware that two-feet beds are sometimes worked to advantage when the coals happen to be of good quality, and are favorably situated as to ready drainage.

There will be no necessity for working in any of the thin beds for ages to come, as there is such an extensive area underlaid by larger veins.

I shall give an account of the outcrops examined by me, and by consulting the map of your lands, you will perceive that the coal is proved to exist under the village of St. Mary's, and all the land immediately around that place.

There are also numerous exposures of outcrops of coal beds on the road-side, and in the banks of small streams, or runs as they are called; their importance is not yet developed by mining operations, so it is impossible to estimate them at present; those here described are beds that have been sufficiently opened to demonstrate the quality of the coals and their thickness.

Dr. C. R. EARLEY'S coal-bed exists south west of Centreville, on the bank of a small stream called Toby's run, where it crops out and shows itself for a considerable distance in the rocky bank on the brook. The strata, including the coals, dip to the northwestward 5°, and the course of the outcrop is N. 30° E.—S. 30° W. The principal bed is 3 feet 9 inches thick; the coal is of good quality; this is underlined by about 20 inches of fire-clay, and is overlaid by slaty cannel coal and bituminous shales. A bed of buff-colored limestone underlies this coal, and is seen in the brook below—another bed of coal about 20 inches thick exists above the principal bed, but since it cannot be worked in the same drift with the workable bed, we regard it as of little importance. Not far from this place we find the coal mines opened by Jonathan Keller; this bed is not opened down to the fire-clay, and I could only measure a thickness of coal of 3 feet 4 inches, though Mr. Keller says that it is 4 feet 4 inches thick. There are said to be two beds of coal above this, and one below, but they are not in a condition to admit of examination, the earth having caved in and filled up the openings.

JOSEPH NEIST'S MINE

Is north of the village of St. Mary's, and quite near to it; this bed has been worked to some extent, and furnishes coal for the neighboring smitheries.

Mr. Neist works in the extraction of coals in the winter months, when he has little else to do, and sells his coal for 3 cents a bushel cash at the mines, or for 4 cents in barter.

This coal is underlaid by a good fire-clay and overlaid by shales containing balls of iron ore. The coal is 3 feet 9 inches thick, and dips 3° to the N., 70° W. A drift or level has been driven into this coal for the distance of 55 feet, and on the course of the

dip, so that it is difficult to keep the water from collecting in the drift at its further extremity. This erroneous method of opening the coal mines in the vicinity of St. Mary's, is generally pursued by the people who, finding the outcrops of the beds, follow down upon them without any systematic views to future workings. I shall have occasion to show that nearly all the mines should be opened on the opposite sides of the hills, where the outcrops do not appear at the surface.

MACREADY'S MINE

Is south of the village of St. Mary's, and nearly half way between that village and Centreville. This bed is 3 feet 10 inches thick, and dips to the north-westward 5°. It rests on a bed of fire-clay, and is overlaid by slaty cannel coal and shales, containing balls of hematite iron and carbonate of iron. It is underlaid at some distance below by 9 feet or more of buff-colored limestone, which is exposed on the sides and in the bottom of a small brook, near the mine. Mr. Macready has cut four drifts into the coal, the principal one being 200 feet long. The coals are sent in winter to the neighboring towns for sale.

JACOB TAYLOR'S MINE

Is situated quite near the village of Centreville, and is one of the most valuable in the district. This bed is not less than 6 feet 2 inches thick, but since it was not opened quite to the under-clay, I could not measure its entire thickness. Mr. Taylor says it is seven feet thick. It is certainly in the most important bed of coal yet discovered in Elk County. Samples of this coal proved on analysis to be of the best quality.

A. HOWES' MINE.

This is situated a little north of Centreville village; the coal is 5 feet 6 inches thick, and is of good quality. On the road-side we also saw the washed outcrops of a coal bed; and in a maple grove, called Kersey Sugar Bush, near the residence of John Sullivan, we found the coal outcropping on the side of a run or stream.

THERESA STREET MINE.

This is situated in St. Mary's. This bed is only 1 foot 8 inches thick, and is nearly horizontal. Iron ore in balls and flattened oval-shaped masses also abound, and this opening will prove valuable, chiefly on account of the abundance of the iron ores that can be obtained from it. The broken slaty rocks are compactly cemented by oxide of iron, which forms with them a firm hard pan.

GLOLT'S MINES.

No. 1 is a bed 2 feet 10 inches thick, with about 8 inches of

slaty cannel coal on top. No. 2 is a bed 3 feet 11 inches thick. Both these beds rest on fire-clay. They are separated by too thick a mass of strata to admit of being wrought by a single line of levels and chambers. The lowest bed being thickest will be most advantageous to work.

BUCHEST'S MINE.

The coal of this bed is 3 feet 9 inches thick, the measurement being taken 50 feet in and upon the level or drift. It is 3 feet 5 inches thick at the outcrop. Good coals are obtained at this mine, a level having been driven towards the north some 50 feet to expose the coal under cover, where it is best. Hernhauser's old bank of coal presents a bed of 3 feet thick.

In Paul Street, in St. Mary's, a bed of coal 2 feet 6 inches thick is exposed, and has with it iron ores in the shales, and fire-clay.

Anthony's Coal Mine is in a bed 3 feet 11 inches thick, with a thin bed of slaty cannel coal on top, and then over that 6 feet of bituminous shales, filled with nodules of hematite iron ore.

THE PRIST MINE

Has been opened in a bed of coal 3 feet 7 inches in thickness; a drift of 30 feet in extent being driven into the hill, in a course S. 15° E. The coals are of good quality.

In the Sugar Grove we also found two beds of coal, one 2 feet 4 inches thick, and the other was not opened so as to admit of measurement. The dip of the coal was N. W. 5°.

Now on looking upon the plan of the Company's lands, and noting the courses of the different coal outcrops, which are at right angles with the dips, *it will be found impossible to reduce the number of beds of coal below five*, even taking into account the differences of level of the mines opened.

We shall, however, make the number and order of succession known if we bore perpendicularly through all the strata at some convenient point, and this I advise to have done previous to sinking shafts and establishing regular mining works. Since the coals are most frequently exposed on the southeast sides of hills and ravines, and the general dip of the coal is to the N. W., it is obvious that the coal will be under good cover of rocks on the N. W. side of the moderate elevations of this district, and that the coal should then be sought by sinking shafts, and the levels or gangways will be driven up the slope of the strata, while the water running to sump at the bottom of the engine shaft will be pumped out, and the mine will thus be kept dry.

In some cases it will be practicable to reach the coals by drifts driven horizontally in the northwest sides of the hills, but this will only be in rare instances.

The present method of sinking on the outcrops should be at

once abandoned, as injurious to the future working of the mines, by letting in the water.

Large quantities of excellent iron ore will be raised in working the coal mines, and this should be laid aside in heaps, and be kept for sale to the iron furnaces that will ere long be established. In the ploughed fields nearly every stone seen is a mass of iron ore, containing from 40 to 50 per cent. of iron. These should also be collected for the furnaces.

The value of the gray sandstone, as building material, has been sufficiently proved by its use in building several excellent dwelling houses, and especially in the construction of the large Church of St. Mary's, which is entirely built of this stone in its rough state. The more compact strata of this rock will serve for hearth-stones and tymps to the smelting furnaces.

Chemical Examination of the Coals from the Mines in Ridgway Farm and Land Company's Property, Elk County, Pennsylvania.

Examination of their value for Gas-making.

N°. 1.
Specimen from Taylor's 6 feet 2 inches bed.

100 grains gave Coke	60
Gas	40
	100

N°. 2.
Slaty Cannel, ordinary kind.

Uncemented Coke	76
Gas	24
	100

N°. 3.
Bituminous Coal—Macready's Mine.

Good Coke	61
Gas	39
	100

N°. 4.
Bituminous Coal, outcrop yielded

Coke	63. 2
Gas	36. 8
	100. 0

Chemical Analysis of a sample of the best Coal.

One hundred grains yield,

Fixed Carbon	52. 38
Gas driven off by red heat	40. 00
Gray Ashes	7. 62
	100. 00

The Ashes analyzed yielded,

Silica	6. 22
Oxide of Iron and Alumina	1. 10
Lime	0. 22
	7. 54

The Slaty Cannel Coal yielded,
Fixed Carbon, 32. Gas, 24. Earthy Matter, 44.

Analysis of the Buff-Colored Limestone.

One hundred grains yielded,

Carbonate of Lime	95. 75
Silex	3. 00
Oxide of Iron	1. 25
	100. 00

Lime in 95.75. Carbonate of Lime, $53\frac{73}{100}$.

CHEMICAL ANALYSIS OF THE WHITE CARBONATE OF IRON (IRON ORE BALLS,) OF THE RIDGWAY FARM AND LAND COMPANY'S MINES.

100 grains of this ore yield,

Protoxide of Iron, ...	61. 50
Carbonic Acid Gas, ...	31. 50 diff.
Silex, ...	7. 00
Metallic Iron in 61. 50 Protox.—$47\frac{84}{100}$.	100. 00

The loss by roasting the ore at a red heat is but 24. 75, and the protoxide of the white carbonate becomes peroxide of iron.

By roasting in kilns in the large way, probably the ore will be enriched about 20 per cent. by removal of a portion of the carbonic acid, and the moisture.

Then the ore will produce more than 51 per cent. of metallic iron.

I found no sulphur or other impurities in this ore that would prove injurious to the iron, but now and then balls will be found which contain sulphur, and these should be rejected from the heap. Hematite iron ores, such as are found in the shales, and occur loose in the soil, yield, after having been properly roasted, about fifty per cent. of iron on reduction in the furnace.

In conclusion, I would assure you and the gentlemen associated with you, that I entertain a very high opinion of this valuable tract of land; valuable alike for timber and a productive soil, but still more valuable for its immense mineral resources in iron ores and coals—the great material powers which advance civilization more rapidly than any other means. Iron and coal have made England what she now is, and the time will come when the Northwestern Coal Basin of Pennsylvania will form one of the richest portions of that wealthy State.

ANALYSIS OF THE COAL.

BOSTON, September 20th, 1856.

CHAS. K. LANDIS, ESQ., *Dear Sir:*—I have at last completed the organic or elemental analysis of the sample of coal from the Ridgway lands in Elk County, Pennsylvania, and no v ward to you a statement of the results.

First, I ascertained the amount per cent. of the hygrometric water contained in the coal, and found it to be 0. 75. It contains no sulphur. Then the percentage of coke it will form by heating it to redness, was ascertained to be 67.5 per cent., and the gas discharged was 32.5 per cent. On complete combustion, the coal leaves 9.5 per cent. of gray ashes.

. Having determined these points, I next made a series of organic or elemental analyses of the coal, according to the methods described by Leibig, Will, and Varrentrap; by the use of oxide of copper, chromate of lead, and soda, lime, in the combustions, the aqueous vapor and the carbonic acid in the combustion by the

metallic oxides being collected by chloride of calcium, and a solution of potash in Leibig's bulbs, while in the determination of nitrogen, by soda lime, the ammonia formed was collected by means of chlorohydric acid, and its proportion ascertained by chloride of platinum.

The following were the experimental results obtained per cent. on the dried coal:

Carbon, ...	79.901
Hydrogen, ...	5.316
Nitrogen, ...	0.943

Now, since the coal contained 9.5 per cent of earthy matter, or ashes, it is evident that only 90.5 of the organic matter, or pure coal, was operated upon; hence the reductions are to be made as follows:

$$100 : 79.901 :: 90.5 : x = 72.309$$
$$100 : 5.316 :: 90.5 : y = 4.811$$
$$100 : 0.943 :: 90.5 : z = 0.853$$

100 of the coal yields ashes	9.500
Deduct from 100	87.373
Leaves for Oxygen,	12.527

Then the correct analysis stands as follows:

Carbon, - - - - - - - -	72.309
Hydrogen, - - - - - - - -	4.811
Nitrogen, - - - - - - - -	0.853
Oxygen, - - - - - - - -	12.527
Ashes, - - - - - - - -	9.500
	100.000

It will be seen by comparison that this is very nearly the composition of cannel coal, but the Ridgway coal is superior to cannel in the production of illuminating gas, and its coke is also more valuable. I found the Ridgway coal gas burned with a very rich yellow and highly brilliant flame.

According to Karsten, Cannel coal contains		And according to the analysis by Dr. Ure, the same coal contains	
Carbon, - - - - -	74.47	Carbon, - - - -	72.22
Hydrogen, - - - - -	5.42	Hydrogen, - - - -	3.93
Oxygen, - - - - -	19.61	Oxygen, - - - -	21.05
Ashes, - - - - -	0.50	Nitrogen, - - - -	2.85
	100.00		100.00

And the very fat coal of Albert County (N. B.) yields, according to my analysis,

Carbon, - - - - - - -	75.20
Hydrogen, - - - - - - -	7.60
Oxygen, - - - - - - -	17.20
	100.00

The ashes is but 0.40 per cent.

It appears that Ridgway coal stands between the cannel coal

and the Albert coal in its composition, for Dr. Ure's analysis is undoubtedly the most correct of the two analyses of cannel coal.

Respectfully, your ob't servant,

CHARLES T. JACKSON, M. D., *State Assayer, &c. &c.*

JOURNAL OF MINING LAWS AND REGULATIONS.

The following decision of the Supreme Court of the United States, in the suit between the Minnesota and National Mining Companies, is too valuable with many of our readers interested in the Lake Superior region to be lost sight of. We therefore insert it in these pages, where it will find a permanent record. The parties to the suit are nominal in interest, the suit really being between the two companies above named.

Supreme Court of the United States—December Term, 1855.

James M. Cooper, Plaintiff in Error, *vs.* Enoch C. Roberts,	In error to the Circuit Court of the United States for the District of Michigan.

Alexander W. Buel, and S. F. Vinton, counsel for plaintiff in error; Truman Smith, counsel for defendant.

Mr. Justice Campbell delivered the opinion of the court.

The plaintiff sued in ejectment, to recover a portion of section No. 16, in Township 50 north, of range 39 west, lying within the mineral district south of Lake Superior, in Michigan.

His case affirms that this section has been appropriated by the United States to the State of Michigan for the use of schools, in their compact by which that State became a member of the Union; that the Governor of Michigan issued, in November, 1851, to Alfred Williams, a patent, evincing a sale of that section under the laws of Michigan, in February 1852, that he has a conveyance from the parties, and that the defendant is a tenant in possession, withholding the *locus in quo* from him. The defendant, to support his issue, relies upon a license given in 1844, by the mineral agent of the United States for that district, empowering the donee to examine and dig for lead, and other ores, for the term of one year, and within that term to mark out and define a specific tract of land, not to exceed three miles square, for mining purposes; and, if he should fulfil this and other conditions, he was to become entitled for a lease for three years, with a privilege of one or two renewals under restrictions. The Secretary of War, in September, 1845, executed a lease for a tract three miles square, which the donee of the license has selected, and which included the *locus in quo*, and stipulated to renew it, if Congress shall not have passed a law "directing the sale, or other disposition, of these lands," and if the lessee shall have complied with all the conditions of the present lease, and tendered a bond for the fulfilment of the new lease, as described in the act. This lease came to the Minnesota Mining Company by assignment, and that company, in 1847, and from thence to 1851, held possession of the land described in the declaration, erected valuable improvements, and made successful explorations of copper upon it. In November, 1850, the company applied to the proper officers of the land office to enter the land comprised in the lease, and from thence, till the date of the patent in 1852, the right of the company to secure the *locus in quo* by entry was in dispute in the land office of the United States. In September, 1851, the Secretary of the Interior determined adversely to the claim of the company, and in

favor of the claim of Michigan, and in 1852, upon proofs that the company had complied with the lease, while he re-affirmed his conclusions in favor of Michigan, allowed the entry of the company, but with a reservation of the rights of Michigan. The section No. 16, aforesaid, was surveyed in the summer of 1847, and the portion in controversy in the report of the geological survey of the district, was returned to the land office as containing mines of copper. There was no application to the department of public land to renew the lease held by the company, for the reason (it is said) that the system of letting mineral land of this kind has been abandoned, upon the doubts expressed by the Attorney General in 1846 of the legality of such leases. Upon the trial of the cause in the Circuit Court, the plaintiff moved the court for instructions to the jury, that upon the facts he was entitled to a verdict and that the defendant's patent was invalid. The court refused the prayer, and told the jury "that by the act of Congress of 1st March, 1847, all the mining lands within the district, reported, were taken out of the operation of the general law for the disposal of the public lands, in pursuance of an established policy to reserve from the ordinary mode of disposing of public lands those that contained valuable salt springs, lead mines, &c., that they might be leased or disposed of to purchasers having full knowledge of their value, by reason of the salt springs or mineral ores they contained, at their full value, for the public benefit. That by the above act all the mineral lands reported by the geologist within the district, in pursuance of this settled policy of the government, were appropriated and disposed of without reference to the school reservation, the appropriation of the land being made before the surveys were executed, and before the locality of section 16 could be known. And as it appears from the report of the geologists that the land in controversy contains valuable minerals, and was within the boundaries of the lease under which the Minnesota company claim, and that they had made large expenditures thereon for mining, were entitled to the right of purchase, as provided in the third section of the above law; and having paid for the same, it was a disposition of the land which Congress had a right to make, and was an exercise of power within the grant. That the setting apart of another section adjacent will satisfy the grant to the State."

Our first inquiry will be into the nature of the right of the State of Michigan to section number 16 in the township of that State, and the effect of the discovery of minerals in such a section upon that right. The practice of setting apart section number 16 of every township of public lands, for the maintenance of public schools, is traceable to the ordinance of 1785, being the first enactment for the disposal by sale of the public lands in the Western Territory. The appropriation of public lands for that object became a fundamental principle, by the ordinance of 1787, which settled terms of compact between the people and the States of the North-western Territory, and the original States, unalterable except by consent. One of the articles affirmed that "religion, morality, and knowledge, being necessary for good government and the happiness of mankind;" and ordained that "schools, and the means of education should be forever encouraged." This principle was extended, first by Congressional enactment, (1 Stats. at Large 550, §6,) and afterwards, in 1802, by compact between the United States and Georgia, to the South-western Territory.—The earliest development of this article, in practical legislation, is to be found in the organization of the State of Ohio, and the adjustment of its civil policy, according to the ordinance, preparatory to its admission to the Union. Proposals were made to the inhabitants of the incipient State to become a sovereign community, and to accept certain articles as the conditions of union, which being accepted, were to become obligatory upon the United States.—The first of these articles is, "that the section No. 16 in every township, and where such section has been sold, granted, or disposed of, other lands equivalent thereto and most contiguous to the same, shall be granted to the inhabitants of such township, for the use of schools."

A portion of this territory had been encumbered in the articles of cession

by the States, and another portion by Congress for the fulfilment of public obligations, prior to the ordinance of 1785, and without reference to the school reservations; therefore, uniformity in the appropriation of the section No. 16 was partially defeated.—The South-western Territory was similarly burdened in the compact of cession by Georgia, and similar paramount obligations have arisen in treaties with the Indian tribes who inhabited it. The rights of private property vested in the inhabitants of Louisiana and Florida, and guarantied to them, in the treaties of cession, created an obstruction to the same policy within them. But the constancy with which the United States have adhered to the policy in the various compacts with the people of the newly formed States, and the care which Congress has manifested to prevent the accumulation of prior obligations which might interrupt it, fully display their estimate of its value and importance. There is, obviously, a definite purpose declared to consecrate the same central section of every township of every State which might be added to the federal system, to the promotion "of good government and the happiness of mankind," by the spread of "religion, morality, and knowledge;" and thus by a uniformity of local association, to plant in the hearts of every community the same sentiments of grateful reverence for the wisdom, forecast, and magnanimous statesmanship of those who framed the institutions for these new States, before the constitution for the old had yet been modelled. Has the discovery of minerals of value upon this section been deemed a sufficient cause for its withdrawal from the operation of this policy, and the compact which developed it?

The ordinance of 1785 dedicated the section No. 16 for the maintenance of public schools, and in each sale of the public lands there was by the same ordinance a reservation of one-third part of all gold, silver, lead, and copper mines within the township or lot sold. No reservations were afterwards made of the gold, silver, or copper mines, until the acts of March, 1847. By the act of 26th March, 1804, and the act of March, 1807, every "grant of salt spring or a lead mine thereafter to be made which had been discovered previously to the purchase from the United States, was to be considered as null and void." (2 Stat. at large, 279, § 6; 449, § 6.) These statutes indicate a policy to withdraw from *sale* lands containing these minerals. But the compacts have been made without such a reservation, nor has the usage of the land-office interpolated such an exception to the general grant of the section No. 16 for the use of schools.

The grant of the section No. 16 for the use of schools can be executed without violating the spirit of the legislation upon salt springs or lead mines, and as we have seen, no statute prior to the admission of Michigan to the Union contains an appropriation or reservation of other mineral lands. The State of Michigan was admitted to the Union, with the unalterable condition, that every section No. 16, in every township of the public lands, and where such section has been sold or otherwise disposed of, other lands equivalent thereto, and as contiguous as may be, shall be granted to the State for the use of schools." We agree that until the survey of the township and the designation of the specific section, the right of the State rests in compact—binding, it is true, the public faith, and dependent for execution upon the political authorities. Courts of justice have no authority to mark out and define the land which shall be subject to the grant.—But when the political authorities have performed this duty, the compact has an object upon which it can attach, and if there is no legal impediment the title of the State becomes a legal title. The *jus ad rem* by the performance of that executive act becomes a *jus in re* —judicial in its nature, and under the cognizance and protection of the judicial authorities, as well as the others. (Gaines vs. Nicholson, 9 How. 356.)

The question now arises whether the act of 1st March, 1847, created a legal impediment to the operation of this principle, either by the reservation of the land for public use, or by its appropriation to superior claims. In March, 1847, Congress established a land district in this region for the disposal of the public lands. It directed a geological survey for the ascertainment of those con-

taining valuable ores, whether of lead or copper, and a report to the land office. It provided for the advertisement and sale of such lands, departing in a measure from the usual mode, as to the length of the notice and the amount of price; and in reference to the remainder of the lands, it applied to the usual regulations. To the section containing these directions (9 Statutes at Large, 146, § 2), there is added an exception from *such sale*, section No. 16, "for the use of schools, and such reservations as the President shall deem necessary for public uses." It has been argued that this exception is only applicable to the lands not contained in the geological report, and that the mineral lands were appropriated and disposed of without reference to the school reservation by this section of the act." But it does no violence to the language to embrace within the exception all the sales for which the section provides, and we cannot suppose that Congress could be tempted, with the hope of a small additional price, which is imposed upon the purchasers of the mineral lands, to raise a question upon its compact with Michigan, or to disturb its ancient and honored policy. We think the interpretation which claims this as an exception in favor of Michigan, is to be preferred to that which excludes her from the mineral lands under the compact. And this conclusion is strengthened by the fact that the power to the President to make useful public reservations, is connected in the exception with the school reservations. There could be no reason for limiting the power of the President to a single class of the public lands, and to exclude him from another, in the same district. We conclude that this act does not withdraw the mineral lands from the compact with Michigan.

Did the execution of the lease by the Secretary of War, in 1845, before the survey of the lands, dispose of these lands so as to defeat the claim of the State? The Minnesota Mining Company, at the date of the act of March 1st, 1847, held the unexpired lease by assignment, and continued to perform its conditions until their patent was issued. The 3d section of that act authorized the persons in possession under such a lease, who had fulfilled its conditions, to enter in one tract all the lands included in it, at a diminished price, "*during the continuance of the lease.*" The 4th section directed the sale of the mineral lands contained in the report, but with a proviso, that none of the lands contained in any outstanding lease whose conditions had been fulfilled, should be sold till the expiration of the lease, either "by efflux of time, voluntary surrender, or other legal extinguishment." The act of Congress, of September, 1850, (9 Stat. at Large, 472,) abrogated such of the clauses of the act of 1847 which distinguished the mineral from the public lands, and placed them alike under the ordinary system for the disposal of the public domain, but reserved to lessees and occupants the privileges conferred by the act of 1847. From that time, therefore, the argument "that the mining lands within the district were taken out of the general law for the disposal of the public lands, by the act of March, 1847," lost all its cogency, and the rights of the Minnesota Company depended entirely upon the validity of the lease and the protection accorded to the lessee. The lease expired by "efflux of time," in September, 1848. There was no renewal of the lease, for the double reason, that its original validity was doubted by the highest executive authority, and those doubts were submitted to by the lessee, and because Congress had passed the law for the disposal of the mineral lands, which determined the covenant for renewal, by the term of the lease itself.

Hence had there been a legal impediment to the execution of the compact with Michigan, erected either by the second section of the act of 1847, which separated for some purpose the mineral from other public lands, or by the privileges granted to the lessees or their assigns, in the 3d section of that act, it was removed by the repealing clause of the act of 1850, and the non-compliance with the conditions on which the privileges depended. The section No. 16 was, at that date, disencumbered and subject to the operation of the compact, whatever might have been the pre-existing state.

That compact has not been fulfilled by an assignment to the State "of

equivalent lands, contiguous as may be," under the act of May 20, 1826. (4 Stat. at Large, 179.) Shortly after the passage of the act of 1850, we find Michigan asserting her claim to this section, advertising it for sale, and selling it to the vendor of the plaintiff. We also find the officers of the land office of the United States denying the right of the Minnesota Mining Company to enter the land, and admitting the superior title of the State of Michigan, and finally reserving those rights in the patent issued to the company. We entirely concur with these officers in their decision on the subject of contest for the reasons we have given. We think that the jury should have been instructed that the section No. 16 was vested in the State of Michigan at the date of the entry by the Minnesota Mining Company, and that the company did not acquire title by its patent.

The defendant insists that the title of the plaintiff is invalid, for the reason that the State of Michigan was not empowered by Congress to sell the school reservations. Where such grants have been made to the State, or to the inhabitants of the township for the use of schools, it has been usual for Congress to authorize the sale of the lands if the State should desire it. (4 Stat. at Large, 188, 237, 298; 5 ib. 600.) But this consent was not, perhaps, necessary, and the application for it is but evidence of the strong desire of the State authorities to act in good faith and to keep within the pale of the law. (4 Ala. R. 682.)

The trusts created by these compacts relate to a subject certainly of universal interest, but of municipal concern, over which the power of the State is plenary and exclusive. In the present instance, the grant is to the State directly, without limitation of its power, though there is a sacred obligation imposed on its public faith. We think it was competent to Michigan to sell the school reservations without the consent of Congress.

The defendant further objects, that the officers of the State violated the statute of Michigan in selling these lands, after they were known, or might have been known, to contain minerals. Without a nice inquiry into these statutes, to ascertain whether they reserve such lands from sale, or into the disputed fact whether they were known or might have been known to contain minerals, we are of the opinion that the defendant is not in a condition to raise the question on this issue. The officers of the State of Michigan, embracing the chief magistrate of the State, and who have the charge and superintendence of this property, certify this sale to have been pursuant to law, and have clothed the purchaser with the most solemn evidence of title. The defendant does not claim in privaty with Michigan, but holds an adverse right, and is a trespasser upon the land, to which her title is attached.

Michigan has not complained of the sale, and retains, so far as the case shows, the price paid for it. Under these circumstances, we must regard the patent as conclusive of the fact of a valid and regular sale on this issue.

Upon the whole record, we think the jury should have been instructed, that if they found the facts thus given in evidence to be true, the plaintiff was entitled to recover the premises in question.

Judgment reversed; cause remanded—a venire to issue.

COALS AND COLLIERIES.

A VISIT TO THE LACKAWANNA COAL-FIELDS.

Anecdotes illustrating the increase of the material wealth of the country from the introduction of coal might be multiplied almost indefinitely, and, to one uninitiated, might seem fabulous. Less than thirty years ago, we remember to have seen an enterprising man trying to interest the good people of Newark in the use of the Lehigh coal. In order to test its merits among un-

believers, he put up grates at his own expense, stipulating only for pay in case the experiment succeeded. He had one strong argument in his favor, and that was the price of wood, which, for hickory often reached $8 a cord. By the time it was prepared for the fire it cost $10. Wood was a very serious item in the expenses of housekeeping; and if, as was alleged, a ton of coal costing $4 or $5 would make as much heat as two cords of hickory costing $16, the economy apparently deserved a trial. Our good uncle, for these reasons, allowed a grate to be put in his old kitchen fireplace, and, in spite of the ladies, who condemned the vile stuff, which, notwithstanding their industrious *poking*, often ceased to burn, to their great vexation, he persevered, and pronounced the Lehigh coal a "great invention." A few others did the same, and yet, for years, only a very few tons of the article were consumed in that enterprising city; and the same was true of hundreds of other places, the people of which very reluctantly left the good old ways of their fathers to use this new fuel.

In those days, too, we were well acquainted with the blast furnaces in New Jersey, at Pompton, Winockie, Hamburgh, Mount Hope, and others; and the managers of these never once dreamed that any other fuel but charcoal could be used in smelting the iron ore. When the first rolling mills in Morris County were built, at Dover and Rockaway, the blooms and fagots were actually heated by means of wood, it being then supposed to be the only available material to make a bright and hot flame. A few years ago we were conversing with one of the veteran iron masters of Morris County on this very subject, and, incidentally, he was led to relate an anecdote too good to be lost. One of his early friends, a native of Suckasunny Plains, in Morris County, N. J., went, more than fifty years ago, to Philadelphia, and established himself as a merchant. He was successful, and gradually drew around himself a class of reliable customers. One of these was a lumberman, as we understood, from one of the tributaries of the Delaware. This man dealt largely with the merchant, and for years met his payments with promptness, in the spring, when he brought his lumber to market. One spring he was unfortunate, and the merchant, having entire confidence in him, extended his notes, and allowed him to make fresh purchases. The next spring the man came to the city, but said his misfortunes had been such that he was unable to pay his debt. "He had nothing left, in fact, but a poor forsaken tract of land, which was worthless, and he felt ashamed to ask him to take it, but, as it was all he had, if he were willing, he would make it over to him if he would cancel his debt." To this the merchant agreed. For many years subsequent he paid the taxes, which were small, thinking that by and by he might sell it for some price, or perhaps get back part of his investment by selling the new growth of timber. Many years after the purchase, a shrewd-looking person inquired of the merchant if he owned such a tract of land, and if he were willing to sell it. There was something in the stranger's manner which put him on his guard, and he told him promptly that he did own such a tract of land, which he had never seen, but which he would not sell until he had seen it. The man then told him that the entire tract was underlaid with coal, very accessible to market. On visiting the land, the merchant found that, had he had his choice of the whole region, he could not have selected a tract richer in coal or more favorably situated than that which he had bought of the unfortunate lumberman. The long and short of the matter was, that it became of itself a rich fortune to him. Some time between 1830 and 1840 our friend called to see his old acquaintance, and his "poor, forsaken land" had already furnished him more than $100,000, and its productive wealth still exhaustless.

Such an account seems fabulous, and yet it was related as true. Doubtless there are many, very many, similar cases in which lands, regarded as very nearly worthless, have suddenly proved to be immensely valuable. The change of opinion and practice is also marvellous. If we recur to Newark, illustrating the whole by a part, we are surprised at the comparison of the

coal business now with what it was thirty years ago. Then, not a dozen grates had been built there, but now there is scarcely a house in the city which does not use coal as the principal fuel; then a few tons were consumed a year; but now it can only be reckoned by the hundreds of thousands of tons which are sold to consumers out of the numerous yards along the Passaic, and the Morris Canal. If we look at the manufacture of iron, the change is not less marvellous. A few furnaces still smelt iron ore with charcoal, but the most of the enormous iron business in this country is now carried on with hard coal. The cupola furnaces use this fuel for melting pig-iron for foundery castings. The great blast furnaces at Boonton, Allentown, Craneville, Danville, Scranton, &c., use the same fuel. The puddling furnaces and rolling-mills at Troy, Fall River, Boston, Boonton, Trenton, Scranton, and others, use the hard coal in immense quantities. Look at one or two items of the coal consumption: It is said that at the Boonton establishments some 40,000 tons are consumed a year; at the two great Troy mills some 50,000 tons; at the Scranton furnaces and mills, 100,000 tons. If we were at the pains to examine all the furnaces and iron mills in New-England and the Middle States, the almost innumerable factories which generate steam with hard coal, the inland and ocean steamers which employ this fuel, and countless yards which do nothing but supply hard coal for house consumption, and then contrast the figures with the consumption thirty years ago, it would make a marvellous paragraph. The growth of the coal business is one of the marvels of our age and country. In the trial of coal versus wood, the decision has long since been in favor of the former. Even in thickly-wooded districts of New-Jersey, Pennsylvania and New-York, coal is supplanting wood on the grounds of economy and safety. And here we may incidentally remark, that, during a recent visit to Ohio and Indiana, we were astonished to find how extensively the soft coal is penetrating into the interior of those States, so much so that it will only take a few years to make Columbus and Indianapolis as dingy as Pittsburgh and Zanesville. For many years this coal has been in use along the rivers, but now it is carried into the regions intersected by numerous railroads.

These reminiscences were excited by a flying visit we made, a few days since, to the great Lackawanna coal-fields in Pennsylvania. The immense treasures of iron and coal in those fields, and the means by which they are reached, alike excited our admiration. For several years we have been urging upon capitalists the necessity of opening some direct and ample communication between the coal-beds and this city. We have shown how vast an amount is now consumed in the city of New York and vicinity, to supply which demands we have been principally limited to the Delaware and Hudson, and Delaware and Raritan Canals, and the coasting vessels between Philadelphia and New York. A strike on any of these routes, or any other casualty, shortens the import and increases the price. Ampler means were needed to give steadiness to the import and price; and this necessity increased, by the fact that the number of coal-consumers is constantly and rapidly increasing. It was, therefore, with no ordinary pleasure that we took the cars on the New Jersey Central Railroad at Elizabethtown—this road extends to Elizabethtown Point, and finds the best of water communication with this city—for New Hampton, some eighteen miles from the Delaware Water Gap. This central road has secured easy grades and curves, and is now pushing its arrangements for a double track to Hampton. A single engine can easily draw 800 tons of freight from Hampton to Elizabethtown Point, and the contract with the roads to the coal-beds obliges them to lay the double-track as soon as those coal-roads insure them 400,000 tons of coal to freight a year. The double track will be laid as far as Somerville this fall. A large part of the section west of this town is nearly graded, and, within a year, the work will be completed. This is the first link in the road to the coal-fields, and is laid with the wide gauge.

At New Hampton we took the cars of the Delaware, Lackawanna and

Western Railroad for Scranton. According to charter there are two roads, viz.: The Warren Railroad, from Hampton to the Delaware River, and the Delaware, Lackawanna and Western Railroad, extending from the Delaware to the Great Bend on the New York and Erie Railroad. Substantially the two roads are but one. The eighteen miles of the road in New Jersey is a great achievement. The streams and mountains run in a north and south direction, so that the valleys had to be crossed by heavy embankments, and the mountains overcome by heavy cuttings. In fact, it is rare to meet with heavier work than on this section. It includes a tunnel several thousand feet long, which is not yet completed. Meanwhile, this is avoided by taking a circuit of some three miles further than it will be through the tunnel. The bridges and the tunnels—there are two tunnels—are calculated for the double track, which will probably be laid in the course of another year. This great work has been planned and executed by one of the most remarkable men in New Jersey—John J. Blair, Esq., who has secured the charter and capital in the face of difficulties declared by most to be insurmountable. When finished, the road will be a monument of his business capacity and energy.

The road crosses the Delaware about three miles below the Water-Gap, by a substantial covered bridge. No pen can do justice to that wonder of Nature—the Delaware Water-Gap. It is a worthy curiosity for the lover of sublime scenery to visit. From the Gap the route follows Broadhead's Creek to the base of the Pocono range of mountains. Soon after leaving Stroudsburgh you plunge into a mountain wilderness. To overcome the mountain going westward, heavy but not unusual grades are necessary—in some cases as high as seventy or eighty feet to the mile. As the principal freighting is eastward, this is not a serious objection. After winding along the face of the mountain some twenty or twenty-five miles, you reach the arc elevation, as is said, of some 1600 feet above the river, at the Gap, and your eye wanders over a prospect of extraordinary beauty. The Water-Gap is as distinct at that distance as when you enter it. Rarely does the traveller over any thoroughfare get two such grand prospects as these in one day—the Gap itself and the view from the top of the Pocono range. Having attained the summit, the grades are very easy for many miles, and you go roaring at magnificent speed through the grand old pine forests, which themselves will soon have to ride to town. The last twenty miles before reaching Scranton is by a heavy grade, say of fifty feet to the mile, but with very easy curves. The company are pushing the work of a double track over these twenty miles to completion the present season. This is the more necessary, as the locomotives can only take about 150 tons up that grade; but, when up, they can take twice that weight. As fast as possible the double track is to be laid the whole distance: and within another year the work will be carried forward, nearly, if not quite, to its completion. But, even if it should not be finished in two years, it is gratifying to know that even then a road of such capacity will extend from the very heart of the coal-fields to tide-water at Elizabethtown Point.

It is but justice to say that the gentleman whose energy and talents are so apparent in the Warren Railroad, was as zealous in the accomplishment of this great triumph, and the public are greatly indebted to him for this promising work of utility.

Of the road from Scranton through Leggett's Gap to Great Bend we are not able to speak, except we were told it is as great as that we have been describing, and it is to be finished with a double track. By this division of the road the Scranton coal is finding its way, in large quantities, into Central and Western New York. It goes to Syracuse, Ithaca, Oswego, Rochester, Dunkirk, Buffalo, and other places, and is beginning to find a ready sale for use on the lake steamers. The father of this road is Col. George W. Scranton, who is said to have done more than any other one person to survey and locate the route, and to interest capitalists in it. This was a very laborious and

difficult task, which this gentleman accomplished with consummate ability. The route itself is a hard one, but it was a heavier undertaking to prove to capitalists that it would be for their advantage to expend several millions in building a road from the New York and Erie—not to some city, but to what it then was—a mere wilderness.

The town of Scranton—formerly named Harrison—is quite a wonder. Fifteen years ago, as we were told, there were half a dozen buildings here. A grist-mill stood on Roaring Brook, where are now the Rolling-Mills. Fifteen years ago a gentleman by the name of Henry began the enterprise, which has resulted in what we now see in Scranton. He purchased five hundred and three acres, including the grist-mill, for $8,000—that is, at about $16 an acre. At that time, or soon after, his son-in-law, Selden T. Scranton, was associated with him. A small blast furnace was built, and iron made with the hard coal. The means of getting the iron to market were hard and expensive. They were compelled to cart it either several miles to come to New York by the Delaware and Hudson Canal, or several miles in another direction, to find an outlet by the Susquehanna by Havre de Grace. A few years afterward Col. Scranton joined the enterprise. In 1846 the iron works were enlarged in order to make railroad bars, and it is worth telling, that, by the energy of Col. S., the greater share of the iron for the New York and Erie road between Great Bend and Port Jervis, was carted on wagons from the mills to the places where the rails were to be laid. This facilitated that great work. In 1850, as we infer from a pamphlet before us, John J. Blair invested his great business talent and capital in the Scranton enterprise. Subsequently we find such New York capitalists as William E. Dodge, Moses Taylor, George D. Phelps and others, engaged in it. In 1851, the railroad communication between Scranton and Great Bend was opened, and with it came a new era to the town. The town had grown somewhat, as a matter of course, previous to 1851, but then it received the impulse which made it. Where, fifteen years ago, were half a dozen houses, there is now a town of 7,000 people, with four churches, an immense iron establishment, several extensive founderies and machine-shops, and evidence, on all sides, of extraordinary business life. The men who headed the enterprise did one thing which has proved a capital investment. They built a beautiful Presbyterian church for some $16,000, and an elegant hotel for $40,000, as if to show the world that they really meant Scranton to be a town to be lived in. In fact, it is a delightful place to spend the hot season in, being so high among the mountains.

The original 503 acres purchased are on either side of Roaring Brook, and extend through the town to the Lackawanna. To show how property has advanced, it is well to state that the comfortable building lot on the corner next to the Presbyterian church is now held at $6,000, nearly as much as was paid for the whole tract. We were told another fact of interest. Next to the original 503 acres on the north side, was a tract of 400 acres. Several years ago the owner of that tract borrowed $3,000 of two persons in New York—stipulating with them, that, if they chose, they might, any time within five years, have half of the 400 acres for the loan. This was in 1845. Before the five years expired, the iron company purchased the right of one of these gentlemen in that land for $2,500, and subsequently the right of the other for $5,000, so that they then owned the title to the undivided half of the 400 acres. After considerable delay the court divided the land into two parts, and the company empowered their agent to offer the original owner $5,000 for the right of first choice, which he refused, and, as it happened singularly, chose the very half they did not want. Within a year the original owner has sold out his half to other parties—reserving fifteen acres—for $65,000! That is, the tract valued in 1845 at not more than $6,000, in 1856 is estimated as worth over $130,000. This is far below its real present cost value, and shows how wonderfully these coal lands have increased in value since Col. Scranton pushed his pet road through to the Great Bend. Coal

lands anywhere in this vicinity, which fifteen years ago would not bring $15 an acre, are now worth $500. This is an interesting item.

We cannot close this article without a glance at the great Iron Mills now in full blast. The first thing that struck us in visiting the mills was a coal-opening within a few rods of the furnaces, with a rail-track. On the opposite side of the mill, within a hundred feet, is a new opening, where large quantities of coal are procured. But to begin with the blast-furnaces, we noticed that two are now in blast; one is undergoing repairs, and that one new one is building. The sizes of these may be inferred from the diameters of the *boshes*, which are respectively 15, 17, 18 and 20 feet, with a height of 50 feet. The wind is forced into these furnaces by double, connected lever-beam engines of great power. The steam cylinders are 54 inches in diameter. The two blowing cylinders are 110 inches in diameter, with ten feet stroke. The wind is forced by this apparatus into the furnaces, under an average pressure of 4 lbs. to the square inch. The fly-wheel which regulates the movements of this apparatus weighs 40,000 pounds. In order to have power to drive all the furnaces, and to be safe against accidents, the company are now preparing to build another blowing apartment. The pair of engines will be furnished with cylinders 59 inches in diameter, and blowing cylinders will be 90 inches. Each engine is to have two fly-wheels 28 feet in diameter, and to weigh 75,000 pounds. By this power they will be able to force the air into the furnaces under a pressure of 8 or 9 lbs. to the square inch—a great advantage, as it is found by experiment, that, in order for a furnace to yield to the greatest advantage, it must not only have a certain amount of air, but that the air must be introduced under heavy pressure. Another thing struck us: this air, instead of being introduced at three places, as in ordinary furnaces, is forced in at from nine to twelve places. The advantage of this arrangement is supposed to be the more equal diffusion of the air through the stack.

When the four furnaces are in full blast, they will smelt about 60,000 tons of ore a year, of which one-third is procured near Scranton, one-third from Oneida County, New York, and the remainder from the magnetic deposits in New Jersey. The ores from New York and New Jersey are brought back in the empty coal cars—a very neat arrangement, by which they carry coal and bring back ore. The Oneida ore is boated on the Chenango Canal to Birmington, and there transferred to the cars. The Jersey ores are obtained in Warren County, at the mines near Oxford Furnace. This amount of ore will produce some 25,000 tons of pig-metal. The limestone for flux has been procured heretofore in the vicinity of Scranton and from New York; but now an uncommonly pure article is found near the Water-Gap, which will be used in future.

A little above the blast-furnaces, on the Roaring Brook, we come to the Rolling-Mills. These contain some thirty-three or thirty-five puddling furnaces, which are arranged on a floor, which is a story higher than the stands of rolls.

We were rather astonished to notice, that the balls from these furnaces were prepared for the rolls by the old-fashioned slow process of the squeezer. Winslow's Rotary would come in well for such a place. The rolling of balls into bars, the cutting and fagoting, are done on the same floor with the heating furnaces. The principal product of the mills is in railroad bars, of which about 15,000 tons are made a year. In addition to this, some 2,500 or 3,000 tons of merchant iron, and also considerable amounts of railroad spikes and chairs, are made.

The furnace and mills are estimated to consume the enormous amount of 100,000 tons of coal a year—to mine which and carry it to the works costs about $1 a ton. This does not include its value in the mine. In the furnaces and mills about 500 hands find employment, and 200 more in the coal department. Besides these, the company's machine-shop employs 50 hands; and, among them all, from $25,000 to $30,000 a month are disbursed—a very

handsome sum, truly, to be scattered on a spot which so short a time since was a wilderness.

The company own some 2,000 acres of coal lands, and 6,000 of ore and woodlands. From the Report of the General Agent of the Delaware, Lackawanna and Western Railroad, we learn that, in the vicinity of Scranton, there are eleven coal companies—the estimated product of which, this year, is over 600,000 tons, and in another year they will be able to raise over 1,000,000 tons. As interesting, we also inquired as to the actual amounts of coal sent away by railroad, and learned that the first year (1851) the road to Great Bend was opened, 10,000 tons of coal were sent to market; in 1852 about 50,000 tons were sent; in 1855 about 175,000 tons were sent; and they are now sending northward to Great Bend 40,000 tons a month. On the Southern Division, toward the Delaware, they are now sending about five trains a day, of 250 tons each—that is, some 1,250 tons a day, or some 30,000 tons a month. When the double track is completed to Great Bend and Elizabethtown Point, we suppose it will be capable of sending at least 1,000,000 of tons a year toward New York City, and as large an amount toward Lake Erie. It is a great enterprise; and the energy with which it has been prosecuted deserves to be crowned with complete success; and we do not doubt but it will.

OPENING OF A NEW COAL ROAD FROM THE BARCLAY COAL FIELDS TO THE SUSQUEHANNA RIVER.

A company of gentlemen recently left Philadelphia for Towanda, Bradford County, to attend the formal opening of the Barclay Railroad and Coal Company's road, from the pool above the Towanda Dam to the mines at Barclay summit. A correspondent thus describes it:

The company proceeded from Philadelphia over the Catawissa and Elmira route to Canton, 236 miles, where we arrived at 2.40. P. M. From Canton we crossed eastward in vehicles to Linwood, where we got on board the Barclay Company's cars, and were passed over six miles of the new road, in good style, reaching Towanda a little after dark. We took quarters in the Ward House, and were joined, on our arrival, by many of the citizens of the place.

Wednesday morning, the excursionists, about one hundred and fifty in number, in open cars, started for the mines, and enjoyed, in their ascent, the novelty of a ride upon a new iron road, between mountains in gorgeous autumn dress. No untoward event occurred; and the ascent and examination were made with facility and satisfaction.

The coal lands of the Barclay Company comprise two thousand acres; the coal, which is semi-bituminous, is mined by drifts from a vein five feet seven inches thick, exclusive of slate. At the drift's mouth, the grade of the railroad is 1,228 feet above the grade at the Towanda dam. The length of the road being 16¼ miles, the coal must of course, in this distance, be passed down 1,228 feet from the mining end to the shipping end of the road. And the way this descent is accomplished, and the cars are returned empty to the miners, is at once simple and effectual—safe and mechanical—attesting the professional skill and practical sense of the mind that planned and superintended the construction of the work.

From the drift's mouth, the loaded car passes over a gravitating road, half a mile, descending twenty-eight feet to the head of a chute, which has a fall of seventy-six feet, down which the coal is plunged into a car upon a track below; loaded thus from the chute, the car passes down a gravitating road one and a quarter mile, with a descent of sixty-eight feet to the head of a self-acting inclined plane twenty-six hundred and fifty-one feet long, and with a fall of four hundred and eighty feet. At the foot of the plane, the cars are coupled in trains of twenty-five five-ton cars, and passed on behind a locomotive down fourteen and a half miles of road with a descent of five

hundred and seventy-six feet. At Towanda, the railroad tracks, upon trestle-work, are carried along side a basin connecting with the river pool, and from the bottom of the cars the coal is dropped into chutes with aprons leading into canal boats lying parallel with the tracks above them.

There is therefore no *handling* of the coal, after the miner fills the car in the drift, until the canal boat shall have arrived at her destination with her cargo! No steam power is employed in working the inclined plane, nor is steam used or fuel consumed in working the road at any point, except upon the 14½ miles between the foot of the plane and the canal, whereon the locomotive is run. From the head of the plain to the chute, and from the head of the chute to the drift, the empty cars are drawn up the grade by mules. And to get rid of this mule power, it is proposed to construct, hereafter, a short inclined plane with a gravitating track to return the empty cars.

Down the inclined plane, three loaded cars are passed at a time, and simultaneously, three empty cars are passed up the plane, which has four rails midway where the cars pass, and three rails elsewhere. Loaded cars can be passed down the plane fifteen times in an hour; and the locomotive engine, over its course from the plane to the canal, can make with ease three round trips per day, with twenty-five five-ton cars in a train; so that with one locomotive the company can deliver into canal boats at Towanda, 375 tons of coal per day, and with five locomotives, they could deliver almost five times that quantity every day.

A close view of the location and construction of the road afforded great satisfaction; for it is manifest that the Chief Engineer thought constantly of the owners of the work intrusted to him, because there is throughout its whole length, a confidence-inspiring adaptation of his plan to their purposes. They wanted a good road, and he has given them a good road, without wasting money upon it, by fitting it to the shape of the earth along a mountain stream, and doing no unnecessary violence to nature.

Seventy per cent. of the main road is straight line—the rail is fifty pounds in the yard; on the road at the mines, twenty pounds; the cross ties are laid close together, and average 2,640 in the mile. The maximum curvature has a radius of 567 feet.

From Towanda, boats loaded with Barclay coal can distribute their cargo along the lines of all the canals of New York; *and as the Barclay mines are farther east and north than any other semi-bituminous coal region, they are nearest to the great east and north markets;* and when in addition to this fact, its merits as a fuel for locomotive engines shall have been tested upon some of the trunk roads of New York, a new market will be created for it; because, for this purpose, it is believed to be unequalled.—*Railroad Journal.*

MAMMOTH SHAFT COLLIERY, SCHUYLKILL CO., PENNSYLVANIA.

The Mammoth Shaft Colliery is situated in the town of St. Clair, Schuylkill County, Pennsylvania, and is now in the occupation of Messrs. Kirk and Baum. It was originally erected by Mr. E. W. McGinnes, the propounder of the "McGinnes' theory." The shaft was planned or suggested by Mr. A. Lawton, who was early convinced of the undulating formation of the coal beds of the county. It is 520 feet deep, and is sunk on the Mammoth vein more than half a mile from its out-cropping on the hills. It is large and commodious, containing ample room for a double-acting hoisting apparatus, with wagons capable of carrying 2 tons of coal each, having also convenient pump-ways for double-acting pumps, with intermediate travelling ways for the ascent and descent of the miners. From the bottom of the shaft the gangways branch off east and west with the strata of the vein, which on this set has a run of 5,800 yards, with an average height of breast exceeding 700 yards. This immense bed of coal ranges from 20 to 150 ft. in the thickness, giving perhaps an average of about 30 ft., and is but a small portion of the Mammoth vein, as it exists throughout the country, being independent of the

Seven Foot vein, which is 18 feet above it, and has been cut by tunnel, 25 yards south of shaft. The veins in the shaft dip at the rate of 12°, and are consequently favorable for mining coal, admitting of railroads in every direction, and of the drift-cars being taken into the breasts, which are run off from the main or counter gangways diagonally, or across the dip of the veins, giving a favorable grade to the roads. Here the miners load their own coal directly from the face of their breasts into the wagon, and once handling it is all that is necessary before it goes into the breaker. By this means they have an opportunity of selecting the coal, and leaving the bone, or slate, in the mine, which could not be done where the veins are worked by runs, as they generally are when the incline is over 35° or 40°. The productive capability of this colliery is over 1000 tons per day, and about 1200 tons of coal can be piled in the bins of the two breakers at the shaft and the slope, which are about a quarter of a mile apart. Six engines are employed in hoisting, pumping, and breaking. At the slope there are two hoisting engines, of 30 horse power each, which work in connection, and are so regulated in power that no decrease is ever experienced in motion or strength. A wagon can be hoisted every minute, and so completely and nicely is the power regulated that they can be stopped to an inch. The pumps in the shaft are 14 in. diameter, double-acting, and divided into two lifts. But, perhaps, the most striking and novel feature of these works is the system of ventilation adopted, which is that known as the furnace mode. The new air course, which has been holed so successfully, is a complete triumph in the miner's art. It is 685 yards in length, and 7 ft. by 12 ft. in the orifice, and partitioned off by a brattice into an upcast and downcast course, which was probably the only way in which so long a heading could be driven. The upper course is 9 feet in width by 7 feet in breadth, and the down course 3 feet by 7 feet. It is believed that this one air-shaft will be sufficient to supply the mine with air until the whole of the available coal can be extracted. The coal raised from the bottom of the shaft is the heaviest sent to market, and is as pure and perfect as any found in America. The quantity of slate and bone intermixed is very small, and less than is found in other parts of the same veins, which arises, in all probability, from the fact before alluded to—that the miners have great facilities for selection before sending the coal to surface. The only other feature connected with this gigantic establishment is the surface works, which are very imposing, being composed of extensive blocks of timber, which cannot fail to strike the spectator at once with wonder and admiration at the extent and spirit of our commercial enterprise. America has much to be proud of, but I am inclined to think she exceeds herself in the energy and determination with which mining of every description is prosecuted.

IRON AND ZINC.

MANUFACTURE OF IRON.

Mr. Joseph Gilbert Martien has just filed his complete specification for extending his process to the removal of the sulphur and other deleterious substances which usually tend to lessen the value of cast-iron. After describing the various parts of his previous invention, which are also employed in this process, he states that when the iron to be purified contains sulphur, chlorine is used for the purpose of purifying the iron from the sulphur, and the chlorine being in a gaseous state is blown into the iron, in the same manner as described in his previous patent, dated Sept. 15, 1855, and, either alone or mixed with air, through separate tuyeres, or through the same tuyeres as the air employed in the purifying process. The quantity of chlorine to be used must

depend upon the quantity of sulphur in the iron, being such a quantity as will combine with and carry off the sulphur. When the iron to be purified contains sulphur and also some oxide of iron, hydrogen or carburetted hydrogen (coal-gas) is used, in order to reduce the oxide to a metallic state, and to combine with and carry off the sulphur, such gas is applied in the same way as chlorine, but if the gas is mixed with air, great care must be taken not to mix the air and gas in such proportion as to form an explosive compound.

When iron contains either at the commencement, or at any other part of the process, oxide of iron as well as sulphur, it may be convenient first to use chlorine for the purpose of carrying off the sulphur, and afterwards to use hydrogen or carburetted hydrogen for the purpose of reducing the oxide to a metallic state. In order to assist in purifying the iron from silica, and make it work more kindly, the inventor adds to the iron, as it flows from the blast furnace or immediately after, about three per cent. of oxide of manganese, either alone, or mixed with either of the materials hereinafter mentioned. The inventor prefers to blow this oxide into the fluid metal by means of air, in the same way as the air used in purifying the metal is blown into it, or the powdered oxide may be blown in through the same tuyere as or together with that air. Oxide of zinc may also be used to assist in decarbonizing the liquid metal.

There is a well-known natural mineral or metallic substance called spathose ore, containing carbonates of the oxides of iron and manganese, and some other elements. In order to decarbonize or assist in decarbonizing the liquid iron to be purified, he adds to it about five per cent. of the spathose ore, by preference in a powdered state, and to blow it through tuyeres into the liquid iron, in the same way as the oxide of manganese. And in order to make the iron work more kindly, he uses together with the oxide of manganese or spathose ore, or mixed with them or either of them, about two per cent. of clay which is free from silica, and dries and powders the clay, and adds it to the iron in the same way as the oxides of manganese and spathose ore. When chlorine is not used in purifying the iron, chloride of sodium may also be used, mixed or together with any of the materials above-mentioned; but he does not claim the use of chloride of sodium as any part of his invention. Instead of blowing the solid matters above-mentioned into the liquid metal, they may be added to it in any other way, taking care to stir up the metal, or by other sufficient means to cause them be thoroughly mixed with it.

IMPROVED FURNACES.

Mr. Charles Frow, of Wakefield, provisionally specified some improvements in furnaces, for steamboiler and other purposes, which consist in arranging the furnace with two or more tiers of fire-bars, the lower bars being of the ordinary description, and the fire having an up-draft, whilst the upper fire was a downw arddraft; the flame and smoke being caused to pass downwards through its own fire, and over the fire on the lower bars. Construct the upper fire grate of water tubes, which communicate at both ends with larger tubes connected with the steam-boiler, or with other vessel containing water, or (in cases of boilers in which the furnace or fire-box is surrounded by water spaces, as in locomotive and similar boilers) connect the water tubes forming the upper fire grate at one end with the external water space of the furnace or with a large tube, and at the other end with a water space connected with the sides and upper part of the fire-box or furnace; this projecting water space is continued downwards below the level of the grate, so that the flame has to pass under it before it reaches the tubes or flues. In place of continuing the descending water space below the level of the tubular fire grate, a similar projection of fire-resisting materials may be so arranged as to terminate at its bottom in a horizontal line across the furnace, and

parallel with the surface of the lower fire grate; feed the furnaces by means of a hopper, through which the fuel descends into a chamber, through which it is forced on to the fire bars by means of a plunger moving laterally. Apply a means of obstructing the free escape of the atmosphere from within the furnace by means of water, through or in contact with which it must pass off, or by adaptation of the form of the chimney flue, smoke-box, or other part, at the time that air is forced into the furnace, by which means compressed atmosphere may be obtained in the furnace at the desire of the fire-attendant.

FAULTS IN THE RAIL.

Rails are subject, besides their unequal wear, to three chances of accidents, which may throw the train off the track: exfoliation, bending, breaking.

Exfoliation results from imperfections in the making, or from the rubbing of the rail by the wheel fixed by the brake; bending from a disproportion between the size of the rail and the weight of the train; fracture is produced, when not the result of faults in the making, or atmospheric influences, by the shock from wheels whose tire has been unequally worn. The flange may strike upon the chair, raise the wheel, and cause it to fall upon the rail.

The breaking of rails is common, but upon straight lines it does not often produce serious accidents. It is most dangerous upon curves; and as the causes of it are, in some degree, beyond human knowledge, the means for preventing it cannot be completely pointed out.

In order to understand distinctly these accidents, we must know their origin, whether the fracture commenced with a fissure, which kept on increasing, perhaps for a long time, or whether it was caused by pressure merely, or by the shock of a wheel pasing over a strange body, a super-elevation or bunch upon the rail. Before such an examination has been made, it will be very difficult to give an opinion on the subject; a minute examination into the causes of all breaking of rails upon all roads should be made. It may be shown, perhaps, that the shock of the wheel will only produce fracture in rails not permanently fixed in the chair; if this be so, it would be another argument in favor of rails permanently fixed.

The form of rails does not appear to exert a great influence in their deterioration, for one and the same form, employed upon one road, have remained uninjured by very heavy engines, while upon another, these rails have been broken by lighter locomotives doing the same amount of work.

There is no general rule upon this subject; the diversity in the forms of rails proves this. In this multitude of forms, six principal varieties may be distinguished:—

1st. The double T used in France and England.

2d. The single T used in Belgium.

3d. The Brunel rail, U reversed, in England.

4th. The American rail, with a single head, and large base, or Vignolles rail, T reversed, used in Germany.

5th. The Barlow rail, V reversed, which has been tried in England and in France.

6th. The compound, or Winslow's rail, which is split through the middle, and screwed together, used in America.

Experiments on rails have been made on a great scale upon roads in France. Barlow's and Brunel's rail have been used; the last, at the time when other roads who have used it for ten years, have discarded it. This shows an entire absence of method; a statistical investigation can alone indicate the proper course to be pursued, and we must by it determine the quality of all rails, and their effects in throwing trains off the track; not till then, can a decided opinion be given on this question, or can we see whether the shape of the rail has any influence upon this class of accidents. Such an investigation would determine the form of rail that gives the greatest security, and this would, doubt-

less, be immediately adopted upon all lines. In a problem so simple, as in all scientific questions, there can be but one solution; but science does not enable us to arrive at it *a priori*.

At the present time, however, the tendency is very evident, to give the head of the rail a very convex surface, to prevent the wheels wearing the edge of the rail, and producing exfoliation.

Besides, rails are now made with greater care, particularly since the methods of rolling have been improved to a degree that leaves little to be desired; and the manufacturers, being closely watched by the agents of the company, have a great interest in doing their work well. Those contracting for rails should see that the circular saw is not used in cutting them. This instrument works very quickly, but it has a serious evil of separating the fibres of the iron exactly at the point where it is of the last importance they should be most compact. In many shops the use of the saw has been abandoned, and the rails are cut by the chisel; this process is slower, but it has the advantage of not altering the nature of the iron, and of diminishing, in a great degree, the quantity of refuse pieces.

Rails subjected to mechanical forces, are, at the same time, affected by atmospheric influences; they may break as a consequence of cold, or a high temperature may occasion irregularities in them.

The expansion of rails by heat, may cause them to spring out of line, so as to throw the train off the track. In 1842, on the St. Etienne road, a rail expanded by the heat was thrown ten feet out of line. This shows that the greatest care must be used in leaving the proper space at the joints while laying rails. On the same road, in 1844, some rails, being very much expanded, bent to such a degree that they raised themselves in the chair; the locomotive passing over them pressed down the first rail, and striking against the second was thrown off the track.

A broken rail may cause the wheels to strike against a chair and break it, and thus throw the train off the track.

Chairs not unfrequently break; this may be occasioned by imperfections in the casting, or by the flange striking them, from the tire being much worn. In these cases, as in the breaking of axles, counter rails do not seem to give any security; on the contrary, they increase the danger. It is true, they may arrest the tendency of the wheels to leave the rail, and may be used with advantage on very long viaducts, but they are of little use when the cars assume a serpentine motion, or when they have once left the rail. The wrong position of a counter rail threw a train off the track in 1846, at Irwell Bridge, on the Lancashire Railway.

To prevent accidents as far as possible, great care must be taken in the superintendence of workshops, in the reception of rails, and the track must be very closely inspected at short intervals of time. These things are already done upon all well-managed roads.

INCRUSTATION UPON STEAM-BOILERS.—BY JAMES NAPIER, F.C.S.

The Engineer, in prosecuting his particular calling, meets here and there with formidable interruptions which he has not been able to foresee, and over which he has little control; under such circumstances, he must either lay aside for a time the particular tools of his art, and betake himself to the study of the interrupting cause, or, what is much better, call in the help of others who make such subjects their particular study. An eminent example of these conditions is embraced in the title of our present article. In the working of a steam engine, great quantities of water have to be converted into steam: and as water generally contains matters held in solution, which necessarily become concentrated, there is a great tendency to the formation of deposits upon the inner surface of the boiler, producing series of evils: amongst others, an increased expenditure of fuel to raise the same quantity of steam, the burning of the boiler plates by the increased heat, &c. To overcome this difficulty, the

ngineer must either study chemistry, or call in the aid of the chemist; if not, he will be subjected to quackery of every variety. Feeling the sad effects of caking, he, like the poor invalid, will read with intense interest, the many cures of ailments similar to his own, and will consequently pour into his steam-boiler any kind of nostrum puffed up as having prevented incrustation in some one particular boiler, without ever considering the different circumstances of the case, or the composition of the deposit he seeks to remove, or wishes to prevent.

Our endeavor in the present paper will be to state briefly the nature and cause of incrustations, then to point out the principle upon which a remedy is to be sought, and finally, to examine how far some of the remedies proposed are based upon or agree with these principles.

In the first place, then, we may state that, were it practicable to use distilled water in steam-boilers, no such thing as incrustation would ever take place. Rain water is distilled, and were it practicable to collect rain water for steam-boilers, no incrustation would be found; but whenever rain touches the earth, it dissolves and retains, in solution, small portions of the saline matters; hence, all waters, whether from springs or in rivers, contain earthy matters in solution. River water generally contains less than spring water, but both vary much in different rivers and in different springs, and in different seasons of the year, to an extent often equal to triple the whole contents. River waters may be said to vary in containing from four to forty grains, and spring water from twenty to a hundred grains of extraneous matter in the gallon.

For illustration, we will take an average of 40 grains per gallon. Suppose a boiler converts 1,000 gallons of water into steam in 24 hours. This quantity having been renewed, each gallon will, consequently, on the second day contain 80 grains of extraneous matter, and will go on increasing at the rate of 40 grains every 24 hours. Water, however, can only hold a given quantity of earthy matters in solution; hence, whenever these accumulate to an extent beyond that given quantity, the excess either floats as a loose powder in the water, or settles down to form a solid crust upon the inner surface of the boiler.

The ordinary ingredients in solution in fresh water are:—

Bicarbonate of Lime.
Sulphate of Lime.
Bicarbonate and other Salts of Iron.
Chloride of Sodium.
Different Salts of Magnesia.
Silica.
Alumina.
Salts of Potash and Soda, in small quantities.

Most of these also exist in sea water, and are the matters in combination forming the cake in boilers of sea-going vessels.

The proportions of these ingredients vary so much, that scarcely two waters are alike; in some the sulphate of lime prevails, in others the bicarbonate; but we will take for our illustration the composition of the Thames, as supplied by some of the water companies, the analysis being given by Dr. R. D. Thomson, of St. Thomas's Hospital. The following form the contents of one gallon, in grains:—

Organic matters	3.56
Silica	.24
Oxide of Iron and Alumina	.46
Carbonate of Lime	10.70
Sulphate of Lime	2.18
Nitrate of Lime	.07
Chloride of Calcium	2.11
Carbonate of Magnesia	.50
Chloride of Magnesium	2.10
Sulphate of Potash	2.11
Chloride of Sodium	16.00
	41.33

The organic matters in the above need not be considered in connection

with our inquiry, as they form no incrustation; but it is the other salts which are to be considered in reference to this property. Carbonate of lime is altogether insoluble, but it combines readily with an additional portion of carbonic acid, forming bicarbonate of lime, in which state it is soluble in water; but whenever the water is boiled, the additional proportion of carbonic acid is driven off, and leaves the carbonate insoluble. The carbonate of lime in the above waters will therefore exist in the water before being put into a boiler, as a bicarbonate.

The following table shows the quantity of some of these salts which will be held in solution by one gallon of water, when cold and when hot:—

	Cold water.	Boiling water
Sulphate of Potash	10 oz.	40 oz.
Chloride of Sodium	32 oz.	28 oz.
Chloride of Magnesium	266 oz.	580 oz.
Carbonate of Magnesia	3¼ oz.	......
Chloride of Calcium	540 oz.	Any quantity.
Nitrate of Lime	500 oz.	......
Sulphate of Lime 174 grains	1-3	......
Carbonate of Lime	trace.	trace.
Bicarbonate	1-3	......
Silica......70 grains	1-4	......

Iron oxide, as carbonate, is insoluble, but, like carbonate of lime, is held in solution by carbonic acid, as bicarbonate, which is also decomposed at a boiling heat; however, except in springs termed Chalybeate, iron exists in very small quantities in water.

Alumina is not a very common ingredient in water, except in very minute quantity, and it exists generally in combination with other bases, forming compounds which are very soluble, and are not generally found forming incrustation in boilers.

We may remark also, upon the above table, that the solubility of some of these salts is increased by the presence of others; thus common salt is more soluble in water containing other salts in solution than in pure water; sulphate of lime is more soluble in the presence of sal-ammoniac and salts of soda, than in pure water. These are circumstances well worthy of remembrance in this inquiry.

Suppose, now, a boiler such as that to which we have already referred, containing 1,000 gallons, and evaporating this quantity daily in steam. At the end of four weeks the matters would stand per gallon as per first column, and in one year the result would be as per second column.

	Four weeks.	A Year.
Silica	6.48	84.0
Iron and Alumina	12.42	174.0
Carbonate of Lime	268.90	3,755.0
Sulphate of Lime	85.86	1,116.0
Nitrate of Lime	1.89	24.0
Chloride of Calcium	56.97	740.0
Carbonate of Magnesia	18.50	175.0
Chloride of Magnesium	56.76	787.0
Sulphate of Potash	68.07	819.0
Common Salt	422	5,616.0

So that from this table of the solubility of the salts, at the end of four weeks, there would be a deposit on the boiler as follows:—

Corbonate of Lime	659 oz.	= 41 lbs. 3 oz.
Oxide of Iron and Alumina	29 oz.	= 1 lb. 13 oz.
	688 oz.	= 43 lbs.

And at the end of the year the water would be saturated, and a deposit of insoluble matter as under:—

	oz.
Silica	38
Iron, &c.	396
Carbonate of Lime	8,567
Sulphate of Lime	2,151
	11,187 = 470 lbs.

We do not mean to assert that these would be found in the exact quantities deposited, as circumstances would vary them to some extent; but merely give them as illustrative of the principle of depositions and consequent incrustations. Repeated analyses of various incrustations taken from boilers verify these statements: we have always found them to be composed of sulphate and carbonate of lime—sometimes the one prevailing, sometimes the other, according to the constructions of the waters used; but sulphate of lime is most common, especially in sea-going vessels, where salt water is used.

From these remarks it will be seen that lime, silica and iron are the principal matters in water that form cake, and that any thing added that would render these matters more soluble, would to that extent prevent the formation of a crust upon the boiler; but the matters added to effect this must not have any prejudicial effect upon the boiler or any of its parts, otherwise its cure might be more detrimental than the disease. It will also be perceived, that as these different substances have different characters and chemical reactions, the substance which would convert one scarely soluble salt into one more soluble, might have no reaction upon another; thus, a little muriatic acid would convert the carbonate of lime into chloride of calcium, but would have no action upon sulphate of lime. Hence, neither this nor any other matter can act as a specific for incrustations deposited from waters indiscriminately used.

The means of preventing incrustation may be stated as two: the first converting insoluble into soluble salts; the second preventing insoluble salts adhering to the inner surface of the boiler. This last condition may be effected by the addition of some substance to the water, which will keep the solid matters in a state of suspension similar to that of holding the black color of ink in suspension by a solution of gum; or, as is the case with preventing incrustation upon copper sheathing on ships; by allowing a slight action upon the metal of the boiler, so that the solid particles in the water are prevented adhering to it, but are left to fall loosely and to accumulate at the bottom, and which can be discharged by the blow-off pipe; or when the boiler is emptied may be swept out; whereas, the thoroughly-formed incrustations have to be taken off by chisel and hammer.

Having suggested the principles upon which the incrustations are formed, we will now consider a few of the methods which have been tried or proposed for preventing the evil.

The first we notice is that already incidentally referred to—namely, adding to the water a little muriatic acid. In water such as we have taken for our illustration, this would be a most effective prevention of incrustation, by converting the carbonate of lime into the chloride of calcium, the most soluble of salts, so that at the end of one year, at the rate we have taken, instead of there being 670 lbs. of insoluble matter, there would not be found more than 136 lbs., and this composed of sulphate of lime and silica—these matters not being soluble in muriatic acid. It will thus be seen, that if the water used in the boiler contained sulphate of lime as the principal ingredient, muriatic acid would have no effect; it is consequently not the universal remedy, as has been asserted by the parties recommending it. Notwithstanding the effect of muriatic acid upon carbonates and its preventing a carbonaceous deposit, still it must be used with the utmost caution; for if any more acid be added than is requisite for the dissolving of the lime, the excess will be very prejudicial—firstly, by acting rapidly upon the metal of the boiler; secondly, by being carried off with the steam, when it will, in that condition, act energetically upon joints, stuffings, and every thing with which the steam comes into contact; indeed, to use this acid with safety would require the care of the chemist, and an intimate knowledge of the nature of the water constantly added to the boiler. A correspondent of the "Practical Mechanics and Engineers' Magazine," for 1847, makes the following remarks upon the use of this acid:—

"I myself have given these chemical means a fair trial, and have found them not only expensive but untrustworthy, especially the much-praised ap-

plication of muriatic acid. I have found that the boiler stone (crust) becomes somewhat loosened, but never dissolved; and I have always had afterwards to scrape and remove it. If the dilute acid is allowed to work longer, to effect the more perfect solution, danger is incurred of the metal becoming corroded, especially on those spots where no deposit may lie. This danger is most to be apprehended with iron boilers. It should be considered that the boiler's deposit consists not only of lime, but of many other salts and substances, such as gypsum, &c., which resists the action of muriatic acid."

This aptly illustrates some of the difficulties which a practical man will meet with, in using in his boilers such a questionable substance as muriatic acid, whether using it for dissolving the crust after being formed, as this correspondent had done, or to prevent its formation in the first instance.

The next chemical preventive is that recommended by Ritterbrandt—the addition of sal-ammoniac to the substances in the boiler. Suppose a quantity of this salt added to the water we have taken for illustration; the first action would be, as we have noticed under the table of solubility of salts, the rendering more soluble the sulphate of lime, thus increasing the distance of time before a deposit would be formed by this salt—and it is so far effective and useful. The next action would be the decomposition of the carbonate of lime, and this may be thus represented:—

Sal-Ammoniac.	Muriatic acid Ammonia (Carbonate of Ammonia.)	Muriate of lime, or chloride of calcium.
Carbonate of lime.	Lime (Muriate of Lime.) Carbonic acid	Carbonate of ammonia.

Here then we have formed out of the insoluble carbonate of lime two very soluble salts, not liable to form a crust. And, so far as this reaction is concerned, sal-ammoniac is a preventive against incrustation from carbonate of lime. So that, upon the whole, the pretensions of this remedy may be favorably entertained. Still, theory suggests a practical difficulty (whether practice have proved it we are not aware) namely, that the carbonate of ammonia being volatile at a boiling heat, will pass off with the steam, and as it has a powerful action upon copper and any of its compounds, either brass or bronze, there will be a tendency to corrosion of all the parts with which the water or steam comes into contact. It may, therefore, be a more serious evil than the one it is intended to remove. We are aware that some engineers have spoken in the highest terms of the use of sal-ammoniac, but in no case have we seen published the chemical properties of the water used in connection with it; which, to a great extent, lessens the value of the testimony. However, where no carbonate of lime exists there would be no ammonia given off.

Carbonate and caustic soda have been recommended by high and chemical authority as preventives of incrustation, and many favorable testimonials have been given as to their effects; but upon what principle these effects have been produced it is difficult to see, except from the circumstances already referred to—that the presence of soda renders sulphate of lime and several other salts more soluble than in pure water. And as a statement of the composition of the water did not accompany the testimonials, these serve no purpose, except that of the vender of the articles. We need hardly add that very great caution is required in using soda, either caustic or as a carbonate, for its accumulation will soon exercise a destructive influence upon joints, lutings, cocks, &c., a fact experienced by many who have tried it.

Another proposition is to use the soda along with a little salt, gallic acid, or Tannin. What effects these matters have is not so clear, but the defects referred to above in using soda may not be so great, inasmuch as the soda will be used in less quantity.

Some of the other and not so strictly chemical remedies we will do little more than name: We may mention, however, that each has its advocates, and each may have its advantages under favorable circumstances. Unfortunately, good effects produced in one case have been considered applicable to all. A dyer, who has been annoyed with incrustation, allows some of his waste matters with ground woods to get into his boiler, and finds, to his surprise, that the formation of crust is prevented; he announces the circumstance as a certain cure; many try it without effect, and condemn the whole. In some cases, where dyewood could not be obtained, common sawdust has been substituted, and has been found in some instances to be effective. Hence sawdust of all sorts is used, and even one class of wood sawdust is recommended in preference to another, and each sort has had its term of recommendation; charcoal dust has not been overlooked.

Then come potatoes, whole and mashed, with and without their skins; such distinctions of taste being considered of the greatest importance. Along with these may be ranked the saccharine matters, as sugar, glucose, and the like; also a mixture of coal-tar, linseed water, Castile soap, and Plumbago. This goodly mixture may have its advantage in some cases by its gelatinous property, thickening the water, and keeping the solid earthy particles from depositing upon the boiler; or it may be that organic matters have a great effect in preventing incrustation, by slight charring loosening it when formed.

Another class of cures which may rank with the woods are the astringent substances, viz., solutions of catechu, oak-bark, and the like; these are used extensively in different parts of the country, and many reports state that the boilers are free from incrustation, and the surfaces clean; but the whole circumstances not being given render these statements less generally available. One remark made, however, is important; that insoluble matters do not cake upon the boiler, but settle as a loose deposit, which may from time to time be blown off, or when the boiler is empty, may be swept out. Why such substances should prevent caking is not very clear, except as we have hinted, viz., the organic matters mixed with the crust become charred, and are immediately loosened and washed off, or it may be by such astrigent matter as gallic and tannic acids, having a slight action upon the metal of the boiler, and thus preventing the caking of the insoluble salts; at the same time, this action upon the boiler not being to an extent capable of effecting its strength for a long series of years; that such matters *have* a slight action upon iron, is well known.

To the use of many of these substances there is one universal objection, viz., *priming;* these substances, by boiling, froth up, as soap would, by agitation, and passing off with the steam, impede the action of the engine, and otherwise do hurt. The evils of priming must, therefore, be avoided as carefully as incrustation, and must be considered in any effective remedy. The writer may himself suggest another substance which may be used as preventing incrustation; and he is led to do so from the following circumstances: A boiler had been in use for a long time, but was regularly blown off; on these occasions the parties interested were surprised to find that the water blown off had the color, and possessed much of the appearance of blood; the boiler was repeatedly examined, and always found clean. This red matter was at length subjected to an analysis, and was found to be composed of one part sulphate of lime, and three parts peroxide of iron. The water used was a chalybeate, having in solution carbonate of iron, sulphate of lime, with a little chloride of calcium and other salts. As sulphate of lime has probably the greatest tendency to cake upon a boiler, the only reason we can suggest why it did not do so in this instance was the presence of the peroxide of iron. We may reasonably conclude, then, that if this supposition be correct, the addition of a little peroxide of iron to waters containing sulphate of lime will prevent that salt caking upon the boiler, and there would be no danger of poisoning from the use of this substance. We throw out the hint, and leave the reader to take it at its value. We ourselves do not ground much on an isolated case.

We have thus briefly fulfilled our proposed task, and we trust that what we have written will be found useful in guiding practical men in the application of remedies, and also in inducing them to observe the effects of different proposed cures, always regarding the particular properties of the water dealt with.

If parties would freely communicate the result of their various experiments in preventing the formation of scale, we are convinced that in a short time a suitable remedy would be found, of easy application to every circumstance—not as one grand specific, but each remedy a specific for its own type and class of disorder.

JOURNAL OF GOLD MINING OPERATIONS.

THE GREAT JOHNSON LODE OF QUARTZ.

Last week, in company with Mr. Clayton, the gentlemanly agent of Messrs. Fremont & Co., claimants of the Mariposa Grant, we visited the above lode of quartz, and were amply repaid for a twelve months' journey over a dusty road. Proceeding down the road we were soon opposite the famous Mount Ophir mine, whose abandoned mill and vacated buildings afford a melancholy record of a monstrous failure in quartz operations, the result of bad management or reckless haste. Where once all was stir, bustle and commotion, all is now quiet and motionless; and it is only to be regretted that the $650,000 so foolishly and absurdly squandered by the agents of the Nuevo Monde, were not applied in bringing water into this country. Leaving Mount Ophir, we followed the road leading to Beer Valley, and soon came in sight of a huge mass of quartz rock, on approaching which we discovered oak trees growing between the perpendicular layers of the projecting lode, usually known by the name of the Johnson vein.

This lode of quartz is situated in Bear Valley, its course is nearly due north and south, with a thickness varying from ten to sixty feet. The base, or bed rock of the valley, is of a soft talc slate formation, which has become decomposed by the action of the elements, the fine dust into which it dissolves being blown off by the spring winds, or floated away by the spring rains. The fact that the valley has been formed by the wearing away of the bed rock, is clearly demonstrated by the projecting boulders of the great lode, which here rise up in flat, thick masses, some thirty feet above the surface of the slate, while all around, for a distance of thirty or forty yards, lie detached slabs of rotten quartz.

Leaving the vein and proceeding up the valley, we soon reached the notorious town of Simpsonville, and then turning to the left we suddenly came in view of MacKay's steam quartz mill, now undergoing repairs previous to again commencing operations. This mill has nine stamps, is driven by a twenty horse-power engine, and when in order is capable of crushing eight tons of rock per day. Bear Creek follows along the base of the southern ridge of hills that enclose the valley, and receives the waters from the various gulches and ravines, which, in winter, run with great rapidity and considerable volume. During the summer months the creek goes nearly dry, and but few miners work along its banks. Following up the valley, we came to the road made along the mountain by the Nuevo Monde Company, an English company who leased this lode of quartz from the Merced Mining Company. The hill through which the vein passes has been tunnelled at six different points, and the vein, cross-cut in many places, shows a thickness in one part of over sixty feet.

Parts of this monster lode are designated as the Josephine and Pine Tree leads, and the rock, taken *en masse*, is unequalled in richness, and the vein, taken as a whole, unsurpassed in width and length, by any lead within the limits of the State.

Some idea may be formed of the extent and richness of this mine, when it is considered that there is sufficient amount of rock now lying on the surface of the ground to supply twenty mills for five years, supposing each and every one of the mills to crush at the rate of 100 tons per day; and when the fact is added to this, that the rock, according to the returns made from the crushing of three or four hundred tons of the same, will average sixty dollars per ton, it can scarcely fail to impress the reader with some idea of its vast mineral wealth. One ton of the quartz was taken promiscuously from this ledge and sent to San Francisco, where it was crushed, and the following are the returns from the same, after being reduced and the metal extracted:—

The gross yield of the quartz was not given with the returns. The net yield, after paying freight, and cost of reduction at the works, was		$122 00
Freight to San Francisco	$23 00	
Cost of reduction	100 00	
		123 00
Net profit		122 00
Total		$245 00

This vein or lode of quartz is now the subject of litigation between Mr. Johnson in his own right, and Mr. Clarke, as the representative of the Merced Mining Company. It appears that the latter gentleman, in the name of the Merced Mining Company, obtained an injunction from the District Court to restrain Mr. Johnson from working the ledge, and that the injunction was made perpetual after a hearing before Judge Burke, whereupon Mr. Johnson delivered up possession of the vein to Mr. Clayton, for and in behalf of Mr. Fremont.

The English Company leased this vein from the Merced Mining Company, and shortly before their failure, had placed the ledge in a most favorable condition for working; but like all other attempts at mining made by English operators in this country, they have succeeded effectually but in one thing, and that is, the spending of large sums of money without credit to themselves, or without benefit to others.

The grant professed to be held by Messrs. Fremont & Co., if made available by the introduction of water, may justly be computed as worth $10,000,000 of money, the Johnson lode itself being valued at over a million. In our opinion, it is more than probable that it was a knowledge of the value of this grant that induced the abolitionists to nominate Mr. Fremont for President. But we have our doubts whether this or any other mining grant can be rendered effective in this political campaign without water to develope the mines embedded in the soil.

The gold in the Johnson lode is disseminated through the rock, or runs in seams parallel with the face, never coarse, and is valued at $16 per ounce. By cutting a road down the Merced river, thousands of tons can be carried down the hill, at little cost, and a large water mill can be erected, at a cost of little over $6,000, that will crush forty tons per day. The quartz has nothing vitreous in lustre, not brittle—fracture conchoidal—opaque, and yields readily to the hammer. The lode is encased between thick walls of talc slate, which are strongly impregnated with sulphates of iron and copper. Scarcely a boulder can be broken without showing gold in quantities sufficient to convince the mind of the observer of its extreme richness. The lode is well opened for working to advantage, and a capital of $20,000, judiciously expended by sound practical operators, would yield a return of 50 per cent. per month above expenditures, and for several years to come the surface boulders would supply all the necessary rock for crushing. This is but one of the numerous evidences of the country's wealth. This vein can be traced for miles, in its course through hill and dale, with gold visible in all the boulders, when broken and

exposed to view. There are a number of veins of quartz within our limited knowledge, which, though not so extensive, are equally as rich, and all that is wanted to make them add to the wealth of the State is water. The people of this country are very forbearing; but "there is a point where patience ceases to be a virtue," and there is another equally as truthful an adage, "that God helps those who help themselves."—*California Democrat.*

PLACER MINING SUMMARY.

The season of the year has now arrived when little can be done on the hills. Even the ditches are fast giving out, and miners have generally betaken themselves either to quartz or the river beds. The unusually low state of the rivers the present year affords great facilities for fluming, and there can be no doubt that those who have good river claims will be richly remunerated for their labor and money.

Fluming operations will be carried on the present year to a greater extent than ever before. The experience of past seasons has pretty well developed the river beds, and the miner now goes to work with a confidence of remuneration never before so generally felt in this description of mining. The rivers in some parts of the State have been taken up from their beds, and carried for miles along the artificial channels that have been prepared for them. The amount of capital thus invested is immense. Some idea may be formed of the cost and magnitude of these operations, which, were they continuous, would extend many days' journey (indeed we may say many hundreds of miles), from the fact, that at the junction of the north and south forks of the Feather River, the continuous length of flume is set down at 8,000 feet, which has been constructed at a cost of $236,000. This em braces only a small section of the river, and will give but a faint idea of the works that have been constructed the whole length of this one stream.

It is impossible for any one who has not been an eye-witness, to form any adequate conception of the magnitude and cost of any one of the leading features of our mining interest. It is to be hoped, when the next general census is taken, that measures will be matured to collect and bring out these peculiar features of California enterprise. The mining interest of the State has been quite too much neglected. It is not allowed its due influence either in the social or political organizations of the State.

It has heretofore been considered, especially the placer mining interest, as very uncertain, and destined to a very speedy exhaustion. The shipments of last year, which fell considerably below the previous average, have been looked upon as ominous of such an event. Those who have so regarded it have done so without any accurate knowledge or without due consideration. The recent and still continued depressed state of business, and the scarcity of money in the mines, is also cited as another indication that the supply of gold is falling off. The Sacramento Union has recently published several well written articles upon this subject, which we shall find room for in our next issue. These articles are evidently written by some one well acquainted with the history, present condition, and future prospects of the mines. At this time we have only room for the following extract, which we fully endorse as truthful and to the point:

"The present depressed state of the mining interests is principally owing to the immense amount of capital that has been unprofitably expended in developing the resources of our mines during the last two years. This capital has been principally directed from the mines themselves, and generally from the localities where it is expended. It was not only furnished by the miner, but by the tradesman, the mechanic, the lawyer, the doctor, and in some places even by the parson. Such is the epidemic for investing in the natural lottery which nature has prepared for us through all our hills and gulches, that almost every cent that has been made in the mining regions has been invested in it. At the commencement of the excitement, when attention was

attracted only to the prizes drawn, when the hundreds of dollars to the pan in one place, and the thouands of dollars a week in another, were looked upon as securing large fortunes to those who would go in boldly, claims in the more favored regions rose to an unprecedented price, and hundreds of thousands, and even millions were invested in prospecting ground, every inch of which, when reached, it was believed would turn out as rich as the most favored spots.

"Unfortunately, the original outlay was but slight; but this outlay drew after it expenses which led eventually to the expenditure of millions, or to the sacrifice of the sums already invested. Months rolled on, and still the excitement was but little abated. Assessments were paid week after week. Every effort was made to raise money to meet these assessments, and it was not until every means was exhausted, that the claims which were to lead to an easy fortune were given up. The failure opened the eyes of the mining community to the fact, that the greater portion of the ground would never repay the expenses incurred, or even pay for working of it at all. The more prudent sold their claims for what they could get—a sum, however, which even months ago seldom realized the half of what had been expended. Others still held on in the hope of realizing better prices; but the illusion was now dispelled; and if it required any thing more to destroy it, it was discovered that even the rich claims, that had yielded their two and three and four hundred dollars to the pan, would not in the long run much more than pay the expenses of working.

"Mining property now became rapidly reduced in value. Hundreds of enterprises were abandoned, and thousands, and probably millions of dollars, that had been invested in them were totally lost, at least to those who had invested in them. The losses fell upon all classes of the community, even those (and they were very few) who had not been directly engaged in the claims suffered, for all their neighbors were broken. The earnings of the whole community for months had been absorbed by a bubble, which now burst, and nothing remained but worthless tunnels and ditches—worthless at least to those who had made them, but, as we shall attempt to show in a future article, still of considerable importance in developing the resources of the country. This is one of the causes, and we think the principal one, that will explain the present distressed state of business in the mines. There are others, to which we shall again allude, and which are quite sufficient to account for the existing state of things, without supposing that the mines are exhausted."

The Northern Mines, during the past season, have paid better, probably, than ever before. This circumstance is owing in part to the fact that they have not generally been so much exhausted as the Central mines, and in a measure also to the abundant supply of water during the season. In no part of the State has the mass of miners met with so great average success. The hills have not yet been thoroughly prospected, but when the gulches and flats shall have been more generally exhausted, more attention will doubtless be turned to them, and no doubt with equal success which has attended like explorations in older portions of the mines.

The Central and Southern Mines have done moderately well the past season; but a large amount of capital has been expended in heavy adventures, from which but little has as yet been realized. The returns from this investment will tell perceptibly upon another season's work. Considering that the present is the dullest part of the year, and in the height of the dry season, our mining population generally are doing well. Those who have gone into the rivers still have a much longer season than usual—fully a month additional. The time for working the river beds will probably be fully double the usual average. The treasure shipments thus far betoken a better year than the last, and we have the fullest confidence that our anticipations will not be disappointed by the success which awaits that portion of the year which is yet to come.

SUPPLY OF GOLD.

Previous to 1848, or until the discovery of the new gold mines, there existed, both in France and the United States, a double tender by *law*, but only a silver one in point of *fact:* it therefore required but the least change in the relative values of the two metals, and but a slight rise in the price of silver above the rate fixed by the mint, to subvert the legalized medium of exchange, and to substitute gold for silver in general traffic. In the United States, where the legal valuation of the two metals was 1 : 16, and where bank notes supplied, to a great extent, the place of silver coin, the change was rapidly effected. By the subsequent coinage of half-dollar pieces, &c., at a reduced mint standard for home and retail traffic, gold has in reality become the only legal tender in the Union.

In France, however, the monetary revolution is a work of time and slow progress, owing to the legal valuations of the precious metals, which gives a proportion of 1 : 15½, and also owing to the circulation of vast sums of silver coin, which was estimated in 1848 at not less than 2,500 millions of francs, or £100,000,000 sterling. It has several times been argued and proved that so long as there shall circulate in France large silver money, which may be exchanged for the 20 franc pieces at the rate of 1 : 15½, or bought at a premium of 2 per cent., the value of gold and silver will never fall below the proportion of 1 : 15½, though in the other states of Europe, the continual new arrivals of gold certainly show a tendency to lower the proportion.

In casting a glance at the French coinage during the last eight years, we can no longer be in doubt as to the real cause which has hitherto operated to keep up the value of gold in France, or which will bring about a complete revolution in the monetary affairs of the country, as soon as gold shall have entirely supplanted the large silver pieces in circulation. The following is the statement of the amount of coinage issued from the mint at Paris from 1849 to 1855, inclusive, and also the average amounts of gold and silver held by the Bank of France during the same period;

	Coinage.		Amount held by Bank.	
	Gold. Francs.	Silver. Francs.	Gold. Francs.	Silver. Francs.
1849	27,100,000	206,500,000	4,060,000	429,270,000
1850	85,200,000	86.500,000	11,980,000	446,840,000
1851	285,200,000	68,500,000	82,260,000	486,460,000
1852	27,000,000	71,700,000	68.936,000	434,994,000
1853	330,500,000	20.100,000	103,598,000	214,482,000
1854	526,500,000	2,100,000	193,337,000	198,723,000
1855	460,000,000	7,000,000	112,500,000	87,500,000
	1,741,500,000	462,400,000		
Or	£69,660,000	£18,496,000		

Thus it appears that the *gold coinage*, within the last seven years, amounted to about 1,742 millions, while the *bullion* in the bank in 1855, as compared with that of 1851, shows a diminution of about 400,000 francs in *silver.*

The large quantities of gold converted into coin by the mints of France, Great Britain, the United States, and other countries, certainly account, in a great measure, for the employment of the new gold from California and Australia since 1848, yet it does not solve the question, "What has become of the gold, coined or not?" Nor, "What has become of the silver which gold has supplanted in the markets of France and the United States?"

We can only explain these phenomena by the enormous quantities of silver which have for some time past been re-shipped to eastern Asia; and also to the vast sums of money sent to the seat of war in the Crimea since 1854, as we shall endeavor to show. The following is a statement of the precious metals exported direct from this country to the East Indies during the last five years:

	Gold.	Silver.	Total.
1861	£102,280	£1,716,100	£1,818,380
1852	921,739	2,630,238	3,551,977
1853	881,202	4,710,655	5,590,866
1854	1,174,299	3,132,003	4,306,302
1855	947,272	6,409,889	7,358,161
Total	£4,026,792	£18,598,895	£22,625,686

The shipments to India and China from the various ports in the Levant, for three years, were:

	Gold.	Silver.	Total.
1853	£93,528	£848,362	£941,890
1854	48,456	1,451,014	1,499,470
1855	243,239	1,520,240	1,767,479
Total	£885,223	£3,823,616	£4,208,839

Thus about 27 millions sterling of the precious metals, of which about 22 millions consisted of silver, have been sent off by the overland mail within the the five years. A portion of the gold may, perhaps, have been destined for Malta and Egypt; but the silver went exclusively to China and the East Indies.

These large remittances of specie may, to a certain extent, have been the result of the so-called "balance of trade," or rather, more correctly speaking, the balance of payments, which, for several years, has been in favor of the East Indies. The par exchange between the two countries naturally depends on the price of silver, the rupee being a silver coin of 180 11-12 grains standard. When the price of 1 37-40 ounce standard silver is 5s., the par exchange per rupee is 1s. 10 3-10d.; if 5s. 1d. per ounce, the par exchange is 1s. 11d., &c., &c. The remittance from England, including insurance (per overland mail), costs about 3¼ per cent. The following statement shows the average exchange on Calcutta for the Company's bills at 50 days' date:

Years.	s. d. s. d.	Total am't drawn upon India.
1848-49	1 9 at 1 10	£1,189,195
1849-50	1 10 at ——	2,935,618
1850-51	2 1 at 2 2	3,236,458
1851-52	2 1 at 2 2	2,777,523
1852-53	1 10 at 2 0	3,317,122
1853-54	2 1 at 2 2	3,850,565
1854-55	1 11 at 2 1	3,689,678

We see by these figures that while the price of silver has not varied more than 3 per cent., the remittances have increased from £1,189,000 in 1848, to £3,850,500 in 1853-4, or 224 per cent. Some persons ascribe these increased remittances partly to railway projects in India, in which English capital is principally embarked, and partly to the higher price which silver realizes in that country, especially since its withdrawal from general circulation in France and the United States. Though these circumstances may not have been without their influence on the money market, yet they hardly suffice to explain satisfactorily the great drains of bullion, particularly silver, which have taken place within the last few years.

The main cause, we opine, lies in the enormous increase of Chinese exports of silk and tea to England and North America. The quantities of those two articles imported into England during the five years ending 1854, were as follows:

Years.	Tea lbs.	R. Silk lbs.
1850	50,512,384	1,769,882
1851	71,446,421	2,055,082
1852	66,360,535	2,118,343
1853	70,735,135	2,838,047
1854	85,792,032	4,576,709

The declared value of our imports from thence in 1854 is computed at £9,125,000, while our exports thither were only £1,000,000. The North Americans usually pay for their teas in bills upon London, which serve as remittances for goods exported from England to China and the East Indies.

Moreover, the exports of China have *decreased* in proportion as the imports have *increased*, and the difference very nearly tallies with the average amounts of silver sent thither. It is true that a great portion of the silver does not go direct to China, but to the East Indies, and finds its way thence to the former Empire, by means of the mercantile relations existing between them. Previously a considerable portion of the cotton which India now exports to England used to go to China, serving as a part-payment for tea. China had, moreover, payments to make in silver to India for opium imported thence. At present these payments are principally made in bills upon England, and India now draws her silver from this country instead, as formerly, from China.

MISCELLANIES.

THE CORNISH STEAM ENGINE.

The following article, for which we are indebted to the Scientific American, contains many interesting particulars respecting Cornish Engines.

Circumstances have put it out of my power sooner to finish and forward to you this communication. It was commenced immediately on reading your remarks appended to my article on page 123, in which my endeavor was to compress what I had to say into the smallest possible space; and I was satisfied to state merely such facts as would lead to further investigation on the part of those interested in the economical use of steam power.

In your remarks at the close of my former article, you propound to me the following queries; which, with pleasure, I will endeavor to answer:

First, "Should not the double-acting condensing engine of 35 3-8 inch cylinder be considered of equal area with the Cornish engine of 50 inches?"

I answer, Certainly. In my communication of the 29th ult, I was comparing engines of the same power, giving to the double engine every possible advantage, and yet claiming a decided superiority for the Cornish engine.

Your other is, "*Why* is this superior economy?"

It is, first, because a portion of the steam used at any time is made effective in the next stroke of the engine.

But this will be better understood by giving an outline account of the working of the Cornish engine.

Sufficient steam is introduced at the top of the cylinder to force the piston down; the equalizing valve then opening, allows the steam to pass from the top of the cylinder, through the equalizing pipe, to the bottom of the cylinder; this being but a small space when compared with the whole content of the stroke of steam, reduces it but little. The piston then ascends at the required speed (this is regulated by ballast), and before it reaches the top of stroke, the equalizing valve closes, prevents any further escape of steam from the top of the cylinder, the piston compressing the remaining steam until the engine is brought to a stand. This is intended to overcome momentum, and to prevent the piston from touching the cylinder head, serving as an elastic cushion between the two. But it also is an item in the economy of the engine; for this compressed steam, filling the parts and the space between the piston and cylinder head, generally ranged from 1 to 8 lbs. per square inch above the pressure of the expanded steam—reduced as above—in the descent of the piston and the operation of equalizing, thus requiring so much less steam for the next stroke.

For example, take a fifty-inch cylinder loaded to an average pressure of fifteen pounds per square inch on the whole stroke, but being introduced at a sufficient pressure (say 27 lbs.) to expand three-quarters of the stroke, and reducing the steam at the end of the stroke to about 7 lbs., and when equalized, to about 6 1-2 lbs. This steam, when compressed as above, at the upper end of the stroke, will be of say 8 1-2 lbs. pressure per square inch on the piston, left behind, as it were, from the first stroke, again to become effective in assisting in the second stroke.

This superior economy is, in thesecond place, because steam is used expansively, with more effect, in the Cornish engine, than is possible in the crank engine.

Steam being introduced at a high pressure into the cylinder, the piston commences descending rapidly, and acquiring a momentum which carries it (the steam valve having been closed) beyond the point where the reduced steam ceases to be effective, the engine will then turn her stroke, and the piston will ascend some considerable distance without the intervention of valves, and so complete is the turn that a stranger to this motion would think the engine attached in some way to a crank. This expansion is in a great degree rendered effective by the mode of attachment (I speak of pumping water in the usual manner with the Cornish engine.)

The engine raises a weight, and it is the descent of this weight that forces or raises the water, thus permitting great rapidity of motion of piston when steam is applied.

From this mode of operation, the balanced (commonly called "Cornish") valves, and the general simplicity of its construction, there is little or no friction attending its working—so little, indeed, that in calculations nothing is allowed for it, and in an engine of 75 horse power, not more than a pint and a half of oil is used per week of 168 hours, the piston getting tallow.

The crank engine, although the steam may be cut off at the same point as in the Cornish engine, yet from its construction (its motion being regulated by a fly wheel) the same degree of rapidity during a part of its stroke is noe practicable nor even desirable. The fly wheel shaft would break off before such a motion were attained.

Again, in the Cornish engine, the power is applied at the extremity of the weight to be removed, while, in the crank engine, it is applied near the centre, being in subjection to a friction caused not only by the heavy fly wheel, but also by the whole power of the engine pressing on the journals of the shaft. And, further, I am of the opinion that there is a vast deal of the power of the engine absorbed by the fly wheel.

The superior economy is, third, because there is not so much leakage of steam in the operation of the Cornish engine as in that of the double engine.

Theoretically, pistons are steam-tight, but practically there always is more or less leakage; and that engine, to whose piston steam direct from the boiler is applied for the longest period in a given time, is of course liable to the greatest amount of leakage. Now let us compare the two engines under consideration; let them each have ten feet stroke and ten strokes per minute.

In the Cornish engine the piston will descend, steam being applied, in $1\frac{1}{4}$ seconds; the piston will turn at the bottom in 1 second; the piston will ascend in 2 seconds; and will turn at top of stroke and condense steam in $1\frac{1}{4}$ seconds.

In the double-acting engine the piston will descend, steam being applied, in 2 seconds; and turn at bottom of stroke in 1 second; ascend, steam applied, in 2 seconds, and turn at top of stroke in 1 second.

These tables, I do not pretend, are mathematically correct to the most minute fraction of a second, yet they are near enough correct for all practical purposes.

By examining them it will be found (there being in the case of each engine ten strokes per minute) that, in the Cornish engine, steam direct from the boiler is on the piston 1 1-4 seconds per stroke, and consequently 12 1-2 sec-

onds per minute; while in the double-acting engine steam is on the piston 4 seconds each stroke and 40 strokes per minute. Hence, in the matter of leakage, the ratio between the two is as 12 1-2 is to 40. But this is not quite a fair comparison, the cylinder of the Cornish engine being larger in bore than that of the other, the ratio between the two in this respect being as 1-2 is to 1. Now by working out these proportions, we find that the double-acting engine is liable to more than one hundred per cent. more leakage than is the Cornish engine.

Let it be further understood, as it were, as a corollary to the foregoing proposition, that the Cornish engine may be made to perform her up-and-down strokes at any required speed, or, in other words, is perfectly adjustable, thus admitting of the use of just the quantity of steam required by the amount of work to be done, or other circumstances attendant upon any particular case.

And in the fourth place, this superior economy arises because, in the Cornish engine, the condensation of the steam is more effectually performed than in the double-acting engine—a more perfect vacuum being formed.

To understand the action of the Cornish engine in its particular, I will proceed with the description of its working where I left off above, in the consideration of the first reason.

After the engine has been brought to a stand, the piston being again at the upper end of the stroke, the exhaust valve opens, and the engine rests an instant, the first jet of the exhaust forcing all the water, air, and vapor from the condenser, then the injection valve opens, and the fresh stream of cold water effects instantaneously a more perfect vacuum than could otherwise be obtained—then the steam valve opens for the next stroke, &c.

The escape of the exhaust, the injection of water for condensation, and the admission of fresh steam in the Cornish engine, are each separately under the control of the engineer; and, allowing the engine more or less time for condensation, is called by them giving her more or less "hark."

I have given a few reasons which I trust will be sufficient to lead to further research in this surprisingly much neglected subject—the economical use of steam power. These are some of the points in which the Cornish engine has a decided advantage over the double-acting condensing engine. It seems almost impossible to give reliable mathematical demonstrations to prove all of its advantages,—the best tests I know of, after all, being the indicator and the coal heap.

In closing, I would wish to notice Mr. Haine's remarks on page 147.

In his attempt to point out the absurdity of the principle, that "the economy of the engine is as the diameter of its cylinder," he overlooks the long-recognized and universally established principle, that, "the piston should move through a space of from two hundred to two hundred and twenty feet per minute to perform economically.

It would be "absurd" in the extreme, to add to the economy of an engine by an increased size of cylinder, and at the same time, subtract from it by the neglect of some other well known principle.

There are double-acting condensing engines built by the same mechanics, under the care of the same superintending engineers, clothed and attended to in the same manner, cutting off their steam at the same point, and in the performance of which the same reputation is at stake, as is the case with the so-called Cornish engines. And yet the result is as stated in my former communication.

I would be glad, could arrangements be made in such a way that the expense should not fall upon single persons—to accept a challenge from Mr. H., to the effect that the two engines of equal power be tried next to one another, with the forfeiture if our engines will not perform as we say. I to be subject to the forfeiture if my engine will not do its work with twenty-five per cent. less fuel than his; he to be subjected in like manner if it does.

JOHN WEST.

Norristown, Pa.

MECHANICAL NOVELTIES AT THE FRENCH EXHIBITION.

The new metal, aluminum, is displayed in bars about 1 1-2 feet long, and three-quarters of an inch thick; also in the manufactured state, as applicable to balances, watches, cups, forks, spoons, and other uses. It fuses at a temperature between those requisite for silver and zinc respectively, and is particularly remarkable for its lightness, elasticity, brilliancy of color, and freedom from any tendency to tarnish. Its small specific gravity strikes one particularly when a lump of the pure ore is first handled, being 4 1-2 times less than a similar bulk of silver. The French are very proud of this discovery, which is due entirely to the advanced state of chemical science among them, and, though the processes for extracting the ore are at present attended with considerable difficulty and expense, confident hopes are entertained that these will be shortly so far diminished, as to establish with the new metal an important branch of manufactures.

Among the French machinery will be found a very ingenious and simple mode of cutting stone, exhibited by a man named Chevaliere. He causes a wire to run at a high velocity over the surface which he wishes to bisect, and by dropping on it a mixture of sand and water the operation is rapidly completed. The hardest granites yield so quickly to this process, that the inventor can with one-horse power separate it at the rate of a square foot per hour, the wire running at the rate of 40 ft. per second. Using the ordinary saw, the same amount of work would require three-horse power, and would expend 15 fr. worth of material, instead of 1 fr., which is all that the wire costs.

There is also exhibited another novelty of appliance, somewhat resembling this in its character, but used for sawing wood. It is shown by an exhibitor named Perrin, and is simply an endless band of steel serrated at one edge, which, moving rapidly round rollers placed vertically, saves all the time lost in the back action which is usually given to saws. The riband of steel is so narrow that any form of cut may be followed, even to the most intricate and complex mouldings, and the operation is performed with marvellous rapidity and ease, the band travelling at the rate of 4500 ft. per minute. In this way from 60 to 70 superficial metres of moulding can be cut in about 10 hours. Perrin's machine is not the only example of inventive talent applied to woodwork by our neighbors; for the firm of Normand, who are great shipbuilders at Havre, show some excellent machines applicable to their trade, including one especially for shaping out knee timbers, which possesses considerable novelty in its arrangements, and has been much admired.

Three attempts at novelty, either in the generation or the application of steam-power, possess considerable interest, though the value of the practical results to be obtained from them is much doubted by men well qualified to pronounce an opinion upon such subjects. One is Siemens's use of the caloric principle as an auxiliary to steam, and with the view of obtaining a large economy in the consumption of fuel. Another is Gray's engine for obtaining direct rotatory action; and the third is a French invention, for generating steam by friction—a curious philosophical toy, which may perhaps be turned to useful account hereafter, but which at present is unequal to any greater effort than sounding vigorously at intervals a whistle attached to the apparatus.

Froment, Fontaine, & Co., show some valuable improvements in the application of water to turbines, by which large bodies of water with a small fall yield better results than can be obtained from any water-wheel. The turbine itself is peculiarly a French motive-power, and, singularly enough, has never been used in England to the extent which its merits appear to justify. Now that so many of our most ingenious and enterprising countrymen are over there, scrutinizing every thing that promises to be useful to them on their return, it might, perhaps, be found advantageous to examine into the working of this machine, and to consider carefully whether we might not profit by its use.

The French builders in constructing houses appear to use beams of rolled

iron, instead of wooden timbers, for the joists of their floors, and of these, which are made in a hollow angular form, to combine strength with economy of material, there is a considerable display. Whether this is, upon the whole, a better plan than that followed in England, we do not pretend to decide, but the fact is worth mentioning on two grounds—first, as apparently offering greater security against fire, and, next, as tending to give increased stability to the different apartments of dwellings, which with us frequently shake about like piles of jelly, at the slightest movement.

Among the novelties of British machinery, a machine, shown by Cripps, of Manchester, for engraving patterns on cylinders to be used in cotton printing, deserves particular attention for the ingenuity and simplicity of its arrangements. The visitor, in quest of what is new and valuable, should also examine a metal-clipping machine, exhibited by an American named Richmond, and which does its work admirably, whether in straight lines or curves, leaving the material separated with perfectly smooth edges.

There is a beautifully and cleverly-contrived model of an apparatus for the downcast shafts of mines, enabling the miners to ascend and descend without fatigue, the minerals to be carried up readily to the surface, and the levels to be kept free from water by pumping.

Bianchi's air-pump, for producing a perfect vacuum, and by which the curious chemical experiment of solidifying liquid laughing-gas is realized, deserves to be included among the novelties of the Exhibition; and the composing and distributing machine in the Danish department, and the Swedish calculating machine; and the beautiful dye alizarine, extracted from madder; and Kiahlmann's process for silicifying: and Gentel's, of Vienna, discovery how to transmit double messages by telegraph instantaneously.

HYDRAULIC ROCK DRILL.

Among the inventions not yet noticed, the one most novel in its inception, and remarkable in its operation, is the Hydraulic Rock Drill, by J. Echols of Columbus, Georgia. The rock-drill is provided with two cup-shaped collars, the hollow sides facing toward each other. A line of hose leads from an elevated reservoir and throws a stream first upward against the upper cup, then downward against the lower one. The force of the water thus applied keeps the drill continually leaping with great force; and considerable ingenuity is displayed in working out the details so as to secure the fullest effect of the water, properly rotate the drill, and make the position of the cups and of all the parts self-adjusting as the drill penetrates into the rock. The water flies about merrily within the small glass room in which it is inclosed, but this may in practice be avoided by giving the parts a slightly different form, and inclosing the whole in a suitable ring or case. The simplicity, lightness, and portability of this machine constitute its chief advantages, and these are so important as to make practicable the employment of this drill, even where a steam-pump must be employed to impel the water. There is a loss of effect in the transmission of power in this matter, similar in kind to that of using water by an undershot or a turbine wheel; but, rightly managed, this loss may be reduced to a very small percentage, and the difference between the stretching a hose across a ledge and the arranging of cumbrous machinery with belting or shafting, is sufficiently great to atone for many inconveniences.

THE NORTH BRANCH EXTENSION CANAL.

We are gratified to learn, from Wilkesbarre, that the water has been let into this new line of our State improvements, and that it is now open to navigation its entire length. Already boats loaded with anthracite coal have been sent up to the State of New York, to be exchanged for cash or for the agricultural productions of the fertile region bordering on the lakes. At the New York State Line the North Branch Canal is connected by the Junction

Canal with the Chemung Canal, at Elmira, thus opening for the rich coal fields of Wilkesbarre and Pittston a wide and extensive market, from which they have been hitherto entirely shut out. This cannot fail to add greatly to the wealth and enterprise of that section of our Commonwealth; and gives the fullest assurance that the North Branch extension will be one of our most productive lines of improvement, and from which the State will eventually reap a large revenue.—*Pennsylvanian.*

NORTHERN CENTRAL AND LYKENS VALLEY RAILROAD.

The connections between the Northern Central Railroad and the Lykens Valley and Auburn and Susquehanna Railroads at Dauphin have been made, and the Lykens Valley and Short Mountain Coal Companies will commence sending their coal by these avenues to market in a few days. We learn that there will be no increase in the supply of the Semi-Anthracite from this region the present season, owing to the uncertain navigation of the canal—but since this new avenue to market has been opened, arrangements will be made the ensuing winter to increase the supply about 50 per cent. During the whole of the present season the orders have been in advance of the supply.

The Northern Central Railroad Bridge across the Susquehanna at Dauphin, is progressing rapidly. It will require about 18 months to complete it.—*Pottsville Journal.*

MINERAL RESOURCES OF SOUTH-WEST MISSOURI.

The almost boundless mineral wealth of South-west Missouri is just beginning to develope itself. But little over a quarter of a century ago, and the foot of the white man had scarely trod, where now are countless numbers of enterprising and industrious people, engaged in digging from the bowels of the earth huge masses of ore, rich beyond calculation, even in its native purity; and scarcely a day passes but can be seen passing through our town, large numbers of persons (and not a few of whom are possessors of large capital), wending their way to the rich mineral regions of Newton County; and these capitalists, too, are not of that floating class of population, who seek a home only for the moment, but they go with their families and their slaves, to found for themselves a permanent home—knowing that the future will bring them a rich return, in the vast increase of the value of real estate.

About eighteen months ago, we are informed, a Mr. Foster, a gentleman of considerable experience in mining affairs, made the discovery of lead in a portion of what is generally known as Oliver's Prairie, Newton County. He continued his researches, and was eminently successful—finding, in fact, that the entire county for many miles in extent, was embedded with lead ore.

Some twelve months ago, Mr. Brock, an old gentleman of sterling worth and integrity, in connection with another individual, commenced digging in the region where the mines are located at present. Mr. B. took up large quantities of mineral, and afterwards sold his claim for about twenty-two hundred dollars to a gentleman who is yet taking up abundance of ore.

At the Oliver's Prairie mines, they have at present three furnaces in operation, and two more in process of construction, nearly completed. The price paid for the ore when taken up heretofore, has been twenty dollars per thousand; but we understand that a firm of heavy capitalists from Washington County are erecting a steam furnace, and offer to pay twenty-five dollars per thousand. The population of this place is about 2,000, and fast increasing. There are two stores keeping a general assortment of merchandise; and it is contemplated that some two or three others will be open shortly.

Though Newton as yet holds the palm for minerals in South-west Missouri, there are other counties which are not far behind her. Jasper contains a large area of mineral ground, and the several furnaces therein have not as yet been long idle for lack of material, and as far as discovered there seems to be no diminution in quantity or quality of her minerals.

During the summer of 1845, Mr. S. K. Cotter, a citizen of this place, dis-

covered lead on Rock-house creek, a tributary of Flat creek, about two miles above what is now known as Burrows' Mill. In one place he found a sheet of ore an eighth to a quarter inch in thickness, running into a hill, exposed to view some thirty or forty feet, and at the same place was a solid block of ore some three or four inches thick, running into the hill.

Lead has also been found at several different periods near this place, and the possibility is, that the greater portion of the whole country hereabouts abounds in this rich mineral. Thus viewing the facts, we surmise it only needs be known to men of capital and enterprise, and South-west Missouri will not be long in assuming, where she will rightly belong, the front rank among the different sections of Missouri; for, exhaust her minerals, and she has a climate and soil unsurpassed by any other portion of the State.

AMERICAN SHOVEL.

In the last century most of the shovels in use, hereabouts, were of wood—shaped out by the farmers and then "shod" or edged with iron or steel, by the blacksmiths. About four score years ago, in Bridgewater, we think it was, Mr. John Ames began the manufacture of shovels. He used American iron, and the bars were brought from neighboring forges by his own son, carrying the load before him on horseback—say two bars at a time. The rolling, shearing, hammering, &c., was done at his shop; the handles were made by cabinetmakers. At this period a Mr. Dyke was also engaged in North Bridgewater, in the same business. During the Revolution there was a great demand for guns, and Mr. Ames contracted to furnish these weapons of war to the Continental army, and abandoned the making the implements of peace. After the struggle was over, he turned his ingenuity to the fabrication of knives and forks and scythes, then much wanted.

It was about 1800 that the youngest son of John, Mr. Oliver Ames—who, though more than three score and ten, is still hale and active, and at the head of the firm we shall refer to presently—recommenced the making of shovels at Bridgewater. He changed his location several times, having his shop in Bridgewater, Plymouth, and Easton, respectively, until 1814, when he settled permanently in the latter town. From 1814 to 1820 he turned out from eight to ten dozen per diem. In 1821-22 there were but two shops. A want of water led to an increase of the number; and privileges were obtained, and a shop built in Braintree, in 1822, in West Bridgewater in 1829, and in Canton in 1848. These, carrying nine trip-hammers and five grindstones, still belong to the concern, being, as it were, tributary colonies to the great central establishment. In 1845 Mr. Ames took two of his sons, Oliver and Oakes, gentlemen now widely known and highly respected, into partnership. Several of the third generation are employed as clerks and overseers; so that the manufactory is a sort of "family affair," and no small affair either; since it is managed with consummate system and skill, and is made, indirectly at least, to produce something besides material wealth. Of its character and magnitude we will now endeavor to give our readers some idea.

The village of North Easton, in population and prosperity by far the largest part of the town to which it belongs, is situated in Bristol County, about 22 miles from Boston. The natural scenery is pretty, the soil fair, but there is nothing specially attractive about the place, as such; and the editor of "Harpers' Gazetteer of the World" appears to have been lamentably ignorant of its chief glory. That reliable (?, if this is a specimen of its accuracy) work speaks of saw-mills and grist-mills, without saying a syllable about the shovel factory—the part of Hamlet left out with a witness. As a matter of fact here is a thriving community, of some 2,000 souls, quite homogeneous, comfortable and independent—made what it is, with its cottages, churches, schools, &c., almost entirely by the wise enterprise, the truly philanthropic mechanical skill and business talent of a single "house," or "household," perhaps we should say.

The main building of the factory—called the "Long Shop"—is two stories high, 255 feet in length, with an L 95 feet and an engine room 40 feet, built of stone obtained hard by. Then there is another stone edifice recently erected, where ten trip-hammers are put in operation by one of the finest steam engines (250 horse power) we have ever seen—and the same may be said of its rival, somewhat less in size, in the "Long Shop." Besides these main structures, there are six hammer shops (all the hammer shops give 24 trip-hammers), one grinding shop with five stones, and one shearing shop.

Within the "Long Shop," principally, are the various machines, invented and arranged by Mr. Ames, senior, and his son Oliver. These are full of interest, both on account of their labor-saving value and the nicety of their operations. Here knives cut iron and steel plates, rapidly and smoothly as Saladin's scimetar cut the silken scarf, dies shape the blades with a single pressure, punches pierce and counter-sink holes for the rivets, grooved wheels lay the straps to the handles—and numerous other contrivances perform numerous other operations, with great rapidity and very perfectly. A detail of these contrivances and the work done by hand would be tedious, and not very intelligible on paper; the system must be seen "in action" to be understood. Suffice it to state that it takes 24 different processes to complete a first quality cast steel shovel. All these processes are performed on the premises, except the making of the handles; these, of white ash, are made in Pennsylvania and Maine—the wood from the latter State being preferable from its closer grain. The advantages derived from machinery and the division of labor may be judged of, from the fact that a shovel is finished in about one hour and a quarter; and 300 men being employed, shovels are produced at the rate of one per every *fifteen seconds*, or 200 dozen a day; that is 2,400 shovels in ten hours—720,000 in a year!

To use an "Hiberniaism," one-sixth of the number of shovels are spades; and of shovels proper there are seven different qualities—among which is the long-handled, pointed-blade shovel, preferred by Californians. The stock used in one year is as follows:—

Best Swedish Iron	900	tons
Cast Steel	400	"
Fuel	2000	"
Grind Stones	85	"
Emery	18	"
Vitriol	5	"
Glue	3	"

The amount of sales, the last year, was $600,000. The average price of shovels per dozen, is about $10.

At this establishment are manufactured one-third of all the shovels (six hundred dozen a day) made in the United States. So it is the banner shop, followed at a considerable distance by about thirty other shops, the principal of which are those of the Rowlands, at Philadelphia, and Lippincott, at Pittsburgh, Pa.

The natural increase in the demand for shovels, occasioned by the growth of the population, has been greatly augmented by the construction of railroads and canals, and the discovery of the gold mines in California and Australia. The latter country, at the present time, opens the principal foreign markets—taking from five to ten thousand annually. There is a large exportation also to South America and Canada.

We have headed this article the *American* Shovel, for two reasons:—1. It is the only shovel in use at home, there having been no importation of shovels, of any consequence, for sale since 1828; and 2. For the combination of lightness and strength, and very likely, for cheapness also, it has the preference in the colonies of Great Britain. Here, then, is a decided victory, obtained in a comparatively few years, by our manufacturers; and for this victory we are mainly indebted to the fine establishment at North Easton.

219

MINING MAGAZINE.

EDITED AND CONDUCTED BY

WILLIAM J. TENNEY.

CONTENTS OF NO. IV. VOL. VII.

ARTICLES.

COMMERCIAL ASPECT OF THE MINING INTEREST.

COALS AND COLLIERIES.

Contents.

THE

MINING MAGAZINE:

DEVOTED TO

Mines, Mining Operations, Metallurgy, &c., &c.

VOL. VII.—OCTOBER, 1856.—No. IV.

ART. I.—PREPARATION OF THE ORES OF SILVER-LEAD, AND COPPER, AND THEIR METALLURGICAL TREATMENT AT THE WORKS AT LOZÈRE, FRANCE.—By M. LAN, Mining Engineer.

MECHANICAL PREPARATION.

THE preparatory assortment which the ore has undergone in the mine, has separated it into coarse (Gros) and fine (Menu); but before it is sent to the smelting-house, it is more carefully picked over.

1st. *The coarse* (Gros). Women and children break it up and pick it over by hand, and make three classes:

A—ore of the sieve, } Sent separately to the smelters.
B—ore of the stamps, }
C—sterile. Remains upon the (herdus).

2d. *Fine*, (Menu). Children wash this class of the ore of the mud, after picking it over by hand; they scoop in the ground a small concave space, which they fill with water from the mine; all around this pool they spread the fine ore in a thin layer, which they sprinkle with the water by means of little hollow wooden shovels. The water washes off the dirt which fouls the ore, and deposits the impurity it contains in little basins of 0^m 50 to a metre in depth, and thence passes off. The ore thus purified is sorted with a small rake, which takes up the coarse pieces. The workman afterward separates the sterile, of which he makes a particular heap, which he does not put on the (haldes) until after the examination of the overseer. After taking away the unprofitable schistose portion (sterile), it is washed again; and that which remains in the heap is then divided into ore of the sieve and ore of the stamps. In short, the products of the cleansing and the classification of the fine ore (Menu) are these:

A—ore of the sieve, } Sent separately to the smelters.
B—ore of the stamps, }
C—sterile. Remains upon the (haldes).
D—sediment and powder. Sent to

The workshop for picking and washing erected at the outlet of the Bosviel, which employs the following force:

An overseer, at 2 francs per day, who is employed about 280 days in a year,

Twenty to twenty-five male or female pickers for assorting the ore, over whom are 5 or 6 breakers. The former are paid at the rate of 0f. 20 per car of 500 or 600 kilogrammes brought from the mine; good pickers can sort 4 or 5 cars in a day of 12 hours; feeble ones three or four cars. Five breakers can prepare 5 or 6 cars of 500 or 600 kilogrammes, and receive 0f. 20 (twenty sous) per car, or about 1 franc to 1f. 25 per day.

There are, besides, in this workshop, some children employed to arrange the ore under the sheds along the railway.

The transportation of the products of this workshop to the smelting works is done by putting the ore from the stamps in cars of 800 kilogrammes, upon a railway along the slope of the mountain to a scaffold placed near the foundry; the ore of the sieve is put in a cart drawn by a horse. The cost of moving the ore in cars is 0f, 20 per car; that in carts is 20 to 25 sous per ton.

The workshops for the mechanica preparation, are located at the confluence of the Luech and the rivulet of Picadiere, at a distance of 7 to 800 metres from the place of sorting the ore. Upon an arch across the Picadiere are located the labyrinths or stowing places and other details of the workshops. At the right of the rivulet is the foundry with its dependencies, and a single wet stamping mill—(bocard à eau); on the left, there are at present three other wet stamp-mills, one for riddles or sieves, the magazine, and the houses of the workmen.

Here, on the opening of the mine in 1781, was located at first a single wet stamp-mill, with sleeping tables and a slime pool. At first the mill had only 6 stamps; in 1786 they were increased to 9. Afterward in 1804 and 1805 the rich or massive ore was broken by hand, and about this time riddles were introduced. In 1821 the shops consisted of—

1. One wet stamp-mill with nine stamps.
2. A first washing place of 3 or 4 pools and 16 twin tables.]
3. A second of 18 twin tables.
4. A riddle consisting of 4 dry stamps, and sieves and tub-shaped riddles.

In 1838 and 1839, the sleeping or twin tables were replaced by shaking tables; the slime pool was preserved only for washing certain products of the riddle. The method of constructing the wet stamps was changed; and from that period to 1850, the workshops or sheds were composed of two wet stamp-mills, with a sufficient number of shaking tables for washing the crushed ore, and the riddle shed.

Finally, in 1850 to 1854 two new wet stamp-mills were added to the old ones, but without any change in their construction.

At this day we find these workshops to consist of—

1. A riddle, comprising a dry stamp-mill of 6 stamps, a grate

or sieve for classification—riddles or sieves, basins of lower deposit, a German box or slime pool.

2. The wet stamp-mill and the washing places needed, Nos. 1, 2, 3, 4; all very similar; in each shop there is in addition to the stamp-mill, shaking-tables, closets and chests for deposit.

We see now the whole of the mechanical preparation at Vialas and the work of the various apparatus. The ore is separated into two classes by the sorting of which we have spoken; these two classes having been brought to the works, are treated separately by a series of operations, the sum of which is presented in the following tables:—

ORE OF THE RIDDLE.

breaking and picking.

a	b	c
massive pile and sent to foundry.	ore disseminates and goes to wet stamps.	siftings, properly speaking, goes to dry stamps, and yields

g 1	g 2
coarse to pass again.	pulverized to be washed.

g 3	g 4
mud passed to the sieve (grillage.)	sand goes to the classificator and yields.

g 5 g 6	g 7
sand No. 1 & 2 sifting.	sand No. 3 yielding twice in the pool.

G 1 G 2	g′ 1 g′ 2	b 1 b 2	g 4	G 3	g 8	g 9	g 10
sifting No. 1 & No. 2 goes to the fine sieve (grillage) after pulverization.	products from resifting.	disseminated goes to wet stamps.	bottom of tub goes to classificator.	sifting refined No. 3 (foundry).	pyrites repassed to same work as ground pyrites.	tailing to repass	muddy water to the basins and to the river.

ORE OF THE STAMPS.

b b 1 b 2 from the sieve.

wet stamping.

β 1	β 2	β 3 β 4 β 5
coarse sand to repass.	sand washed over the shaking tables specially.	fine ground ore, of various and numerous washings, over same shaking tables.

analogous products by one work at two times.

First work.

muddy water to the basins and to the river.	tailings of the table pass to first work.	head of table of second work.

fine ground ore of deposit treated at shaking table as β 2 β 3	water for basins of pyrites.	tailings to repass to same work.	fine mud ore of table sent to foundry.

fine pyritous ore by ore work, like pyritous fine mud ore sent to foundry.

The operations of the riddle are these:

1. The breaking by hand, with picking or sorting

2. The dry stamping.
3. Washing the crushed ore.
4. Classification of crushed ore.
5. Sifting of the grains classed.
6. Refining of the German box.

1. *Breaking by Hand.*—This work is done by a single person armed with a hammer of one to two kilogrammes on a handle of $0^m.60$ to $0^m.70$ in length, (70–100 of a metre). This man makes three lots of the pieces reduced to the size of an egg or less; the first lot consists of the ore when the galena does not appear to be mixed with the gangue except in insignificant quantities; it is the *massif* for *dry fine*. The second lot consists of pieces, which recall the most beautiful qualities of the German *schunez;* the galena therein alternates with very small threads or nodules of gangue The third lot consists of galena in a more disseminated state; it resembles class B of the sortings of Bosviel, and like it goes to the wet stamps.

2. *Dry Stamping.*—The apparatus is very simple; four stamps with cast iron heads fall upon a bed slightly inclined forward.

The second lot is the only one brought to the stamping bed of the riddle; the ore is cast by the man in charge under the stamps, and the coarse pieces are constantly pushed back; the crushed ore is cast upon a rectangular sieve, to which the workman gives a back and forth motion; the mesh is from 6 to 7 millimetres. What remains on the sieve goes to the stamps; that which passes through goes to the washings.

When the work goes on night and day at the dry stamps, the presence of two workmen is required for 24 hours. The utmost which it is possible to pass during this time does not appear to exceed 2 tons or $2\frac{1}{4}$ tons.

3. *The Washing.*—This operation is performed in a small trough, with an inclined bottom, and of $0^m.50$ to a metre in length, to $0^m.30$ to $0^m.40$ in depth. The workman throws in a shovelful of pulverized siftings, agitating them continually under a current of water. The trough is not emptied until it becomes two thirds full. The muddy water, which escapes by an adjacent pipe from the surface of the trough descends to the lower floor; before passing to the river they deposit a sediment in four boxes, the two first of which are 2 to 3 metres long, 1 metre broad, and $0^m.60$ deep; and the other two, 6 metres long, 2 metres broad, and of the same depth. It is here that is deposited the fine mud g^3, usually sent to the sieve or grate (grillage). Thence the waters flow to the river, still passing through great basins outside. All the washed sands remaining in the trough go to the classifier.

4. *Classification.* In principle, the classifier is the same as that called *separation-rütter* of the Hartz, but it is not so long or so complete. This apparatus consists of a wooden frame of a

metre to 1m. 20 long, to 0m. 40 to 0m. 50 broad, upon which are fixed three sieves, two of which are superincumbent. Moving round a horizontal axis placed in the after part, it is inclined at an angle of some degrees from behind forward; the forward extremity is supported by an iron stem fastened to a system of levers dependent from the shaft of the dry stamps. Thence results an alternate and vertical motion, under the effect of which the sands, washed by a shower of water which falls on the crible, circulate over the sieves and are classified according to their size.

The superincumbent sieves are of iron or brass wire, of which the upper is No. 10, and the lower No. 25; next, the grains which pass neither of those have a diameter of 0m. 0025 to 0m. 006. This is the *sifting No.* 1, *raw g*[5].

The grains which pass through the upper mesh and stop at the lower, have a diameter of 0m. 002 to 0m. 00075, and yield *sifting No.* 2, *raw g*[6].

The grains No. 3, which are less than three-fourths of a millimetre, fall into a special box, from which proceeds a trough that conducts them to the lower floor, into a small particular recess by the side of that of the fine mud. Each of the three numbers or classes of sand thus obtained is treated separately; the two first by the crible (sifting), and the last by the German box. A single man, working 12 hours a day, is a sufficient force for the *washing g*,[3]—and the classification *g*[4] of the substances crushed by the dry stamps in 24 hours.

5. *Sifting.*—The sieves (cribles) used for washing Nos. 1 and 2 are circular, in wood bound with iron; they are 0m. 40 in diameter, to 0m. 12 in depth. For sieve No. 1, the wire-cloth forming the bottom has an opening in the mesh of 0m. 003 nearly; that for No. 2, 0m. 00075.

The workman fills the sieve half full of raw sand; holding it by two wooden handles, he plunges it into a tub of water of 1 metre in diameter, where he imparts to it sometimes a gyratory and sometimes a vertical motion. By means of a little scraper he raises three very distinct layers; the first and upper one is poor in galena, and is put aside to go to the wet stamps; the second and middle layer is a product to be repassed the sieve; the third and lower one is very rich ore, comparable with *massif for dry fine* (massif pour fin sec), with which it is elsewhere mixed and ultimately pulverized, before being sent to the grillage (fine sieves.)

In the tub where the sieve is agitated, fine grains are deposited, which pass through the mesh or over the edge. These should be returned to the classificator.

A sifter working 12 hours per day will wash the products of 24 hours' dry stamping.

6. *Refining of the German box.*—The particular recess in which is deposited the sand No. 3, consists of six or eight square basins

of a metre to the side. The sands taken from the reservoirs do not differ either in richness or coarseness of grain, nor does the work of the slime pool sensibly change either of these results.

The German box of Vialas is 2^m. 60 long, 0^m. 50 broad, 0^m. 40 to 0^m. 45 deep; the inclination is from 0^m. 10 to 0^m. 11 per metre; the head is formed of two compartments superincumbent, or one above the other; the lower one is 0^m. 25 long, and the water flows from it like a weir upon the ore in the box to the height of the upper compartment.

This work presents no peculiarity; it is done the same every where—with two trials, of which the following are the products:

First Trial.

(0^m. 50,) *Sand of the head*, put in a heap to be subsequently refined.

(0^m. 20,) *Intermediate part*, considered as the first matter of the same trial.

Sand of the tailing, poor, destined to the wet stamps.

Muddy water, which flows to the river.

Second Trial—(Work of Refining).

(0^m. 50,) *Refining sieve No.* 3 (head of the box), sent to the foundry.

(0^m. 25,) *Sand intermediate*, a product highly pyritous, which is subsequently refined by an analogous labor, and yields a pyritous fine mud (*schlich*) very useful in metallurgical treatment. In this complementary operation the sand of the tailings is considered as poor matter, and goes to the wet stamps.

Sand of the tail, considered as No. 3, raw.

Muddy water, goes to deposit fine ground ore in the great basins outside; these deposits are treated like the mud ore, of which there will be a consideration hereafter.

The work of the German box is done by a single man during the day, who is often out of work in the course of a year.

The products sent to the foundry from the crible shops are, therefore:

1st. The *fin sec*, the *siftings No.* 1 *and* 2 *washed*, stamped together at the dry stamps, are sifted on a cloth from a mesh of 0^m. 003, and afterwards sent to the foundry.

2d. *The sifting No.* 3 *refined, the pyritous sand, and the mud ore or slime;* these three sorts are sent directly to the foundry.

We shall investigate, further on, the richness of the matters from the crible, in discussing the mechanical preparation as a whole.

Whatever may be the origin of the ore or its hardness, after breaking by hand it can no longer be classed as *massif;* it is considered as matter for the stamp-mill; mixed all together, it s subjected to a crushing uniformly fine, and the sands or slime

products by this work go to the washing on the shaking tables. The treatment and the apparatus required are thus very simple; each of the shops contains a certain number of stamps, recesses and basins of deposit; three shaking tables are reserved to each stamp mill. All the operations are comprised as follows:

1. *The wet stamping.*
2. *The classification of the crushed matter.*
3. *Washing the sand and slime ore.*

1. *Wet stamping.*—Without dwelling upon all the details of the stamping mills of Vialas, we will point out the elements essential to be known in order to appreciate their work. The stamp is about 4 metres in length, comprising the cast-iron shoe, which has the form of a right prism—at the base square, of 0^{m}. 15 to the side, and 0^{m}. 20 in height, weighing when new 50 kilogrammes; the shaft of beechwood weighs, in addition, 60 to 70 kilogrammes; the total weight of a stamp is about 120 kilogrammes. The lift of the stamps does not vary; it is 0^{m}. 20 to 0^{m}. 25.

The bed is rectangular; its bottom is quartz beaten and pounded by the stamps, at the commencement, to a thickness of 0^{m}. 15 to 0^{m}. 20; it is slightly inclined from the front backward—that is to say, in a direction contrary to the movement of the water. The back wall of the bed is vertical, like all others, but it is extended by a small inclined plane, on which is passed the ore to the stamps and the water necessary for the work.

In place of a grate or sieve for sorting the broken ore, a kind of syphon is used here—a contrivance like that used in Hungary, but for a very different kind of ore. About 0^{m}. 15 above the bottom, the front wall or side of the bed is pierced throughout its length by an opening of 0^{m}. 015 in breadth, which communicates with a horizontal canal of 0^{m}. 02 in breadth, and 0^{m}. 05 in height, extending the entire length of the bed. It is here that the water bringing over the pulverized ore escapes.

For a battery of 40 stamps, the bed or trough is 1 metre in length, 0^{m}. 35 to 0^{m}. 40 in depth behind, and 0^{m}. 30 to 0^{m}. 35 in front; 35 to 40 centimetres in breadth. The stamps being separated 0^{m}. 15 to 0^{m}. 16 from axis to axis, the division between two adjacent ores is very slight.

In front and close to the bed are channels inclined at the bottom where the powdered ore and the coarse sands for repassing are deposited or settle.

A few words on the work of stamping.

The ore is thrown into the bed; the stamping commenced and continued under a current of water, of which we do not know the exact volume; it must be very considerable, if we rely upon a single experiment made by ourselves; we have poured 150 to 200 litres of water per minute. The finest pulverized ore escapes by the syphon above mentioned; it takes off quantities of pieces

and coarse sand, varying according to circumstances, but especially to the abundance of water and the rapid movement of the stamps. The workman from time to time gathers it with a shovel and throws it into the bed. So far as relates to the water which flows off charged with sand and slimy ore, this goes to the basins of classification.

2. *Basins and Recesses—Classification of pulverized ore.*—The basins of classification and the deposit of pulverized ore which escape comprise:

1st. Four wooden boxes of 1^m. 90 in length, 0^m. 70 in breadth, 0^m. 50 depth, along which two channels run to a square section of 17 to 18 centimetres on the side—one *a* for pulverized ore, and the other *b* leading to the recesses; these channels have little gates or outlets to establish an easy communication.

2d. A recess (labyrinth) consisting of twelve or fifteen basins in masonry 1 metre in length, except the first, of which the section is a little larger. They are placed side by side, and over the whole length run little covered channels furnished with gates or outlets, in order to pass at the proper time the water from one basin to the other. These channels end in grand reservoirs, still larger, whence the water passes to the river.

By means of the outlets in the channel *a* we cause the slimy water to flow into those of the four boxes, which are empty or still free; whilst one is cleared they open the gates or outlet of another, and thus avoid any suspension of labor.

Whatever may be that of these boxes which are filled, the water after having deposited the sand β^2 escapes in the conduit *b* and pass to the basin of the recess of which they regulate the fulness by means of the outlets.

According to the nature of the deposit at the point of washing, we discriminate only five numbers of slimy ore in the basins of the recess,—as the transverse dimensions of these basins differ but little, there is beside but little difference in the richness and fineness of these five numbers.

Each stamp-mill is served by 2 workmen, laboring each 12 hours per day of 24 hours. When the stoppages are not considerable, we can count an average of 10 to 12 tons of stuff passed in 24 hours by a stamp machine of 15 or 16 stamps. During certain months of the year, when water is abundant and other circumstances favorable to steady work, 13 to 14 tons are passed in a day.

3. *Washing of Sand and Slimy Ore.*—To each of these two classes of products the work and apparatus correspond. The three shops or sheds of shaking tables contain one for sand and two for slimy ore of the corresponding stamp-mill.

3. *Working of the Sand β^2.*—The shaking tables consist of a plank strengthened by cross-pieces 4 metres long to 1^m. 40 wide. At the head of the table is a small inclined plane, furnished with

prism-shaped brackets to divide the slime for washing. This apparatus is sustained as usual by four iron chains, of which two are fixed behind, and the two others can be lengthened or shortened by a windlass placed in front. The shaking movement is communicated to the head by a system of bent levers, moved itself by a shaft, and cams common to the three tables in the same shop. Behind and above the head of the table is a circular hopper, where the sand is stopped with the water for washing. This distributing apparatus, like certain revolving tubs used on the borders of the Rhine, is composed of a wooden hopper, in pieces, having the large base 0 . 90 in diameter, the small one 0^m. 10 to 0^m. 135. It is sustained by an iron axis, and terminates towards the bottom in a toothed circle, a communicating mechanism is geared with the teeth of this circle, which makes it turn, and with it the hopper, by jerks, around the iron axle. In this movement, the sands carried by the water fall to the distributor in a small channel placed below, and which opens on the inclined plane at the head of the table.

In short, at the foot of the table are channels or trenches by which the water passing from the works goes to the river or to special basins.

Working the sand β^3 is done in a very rapid manner on these tables; they reach the inclined plane at the head of the tables, and are there divided into little threads which occupy the whole breadth of the table. With a wooden scooper, the workman from time to time removes the stuff from the foot to the head. So far as relates to the essential details of the work, that is to say, the quantity of water used, the continuation and extent of the shake, the inclination of the tables, we have not been able to procure precise and uniform particulars. We refer that subject to the skill and tact of the washing master.

The washing of the sand is done with two trials, and the following are the products yielded:—

First Trial.

$\frac{1}{5}$ of the length down from the head goes to the second trial.
$\frac{4}{5}$ of the tail is regarded as first stuff of the first trial.
Slimy water goes to the river.

Second Trial.

$\frac{1}{5}$ of the length from the head, is fine ore for the foundry.
$\frac{4}{5}$ of the tail passes to the smelt works.
Slimy water goes to the river after passing into special basins, where they deposit very pyritous sand, which is washed in the same manner for fine pyritous ore delivered to the foundries.

The basins of pyrites are usually four in number, 2 metres to 2^m. 20 in length, 0^m. 60 in breadth, 0^m. 40 to 0^m. 45 in depth.

Working the Fine Ground Ore β^4 β^5 β^6 of Various Numbers.—

The tables for fine ground ore (schlamms) differ but little from that for sand; they are constructed in the same manner, and with the same dimensions as the first,—the little falls which present their floor make the only peculiarity. The distributing apparatus on the contrary differs very much. The jerks imparted to the hopper of sand do not answer for delaying the ore, which is very slimy, as it comes from the recess.

There is a *nacelle* adapted to the alternate and continued movement, in which comes a constant little stream of water. This *nacelle* is moved in a wooden box, of a pyramidal truncated form and square base; the bottom of this box slightly inclines toward the conduit which connects it with the table, leaving between itself and the external wall of the *nacelle* a space of some centimetres. It is by this space that the matters delayed in the water of the *nacelle* escape by its oscillatory motion, and gain the conduit which leads to the table.

Apart from this arrangement for delaying and bringing the slime ore on the tables, we have nothing new to state respecting the working of the slimy ore of various numbers and of various products; two trials are made, yielding each time products analogous to those of the sand. We do not mention the quantity of water, the continuity and fulness of the shake, &c., which are details varying with the number of the slime to be worked; these variations in general are very small.

Each shop of three shaking tables is attended by 7 workmen 12 hours. 1 master washer; 3 servants, one for each table; 1 child having charge of the flow of slime and sand on the table and of the clearings; 2 laborers for emptying the basins and transports.

Without comprehending the fine pyritous ore, the average product of a table of fine ore sands is 200 to 250 kilogrammes for 12 hours, but this figure is below what can be obtained by constant labor; the product of a table of sand may be 500 to 600 kilogrammes per 12 hours.

Besides the slimy ores, every shop of three tables produces in addition an average of 50 to 60 kilogrammes of fine pyritous ore, whether sand or slime.

The products sent to the foundry shops for washing with shaking tables belong to three classes, *sand*, *fine ground ore*, *pyrites*.

The force required for a crible shop, the wet stamp-mills, and the shaking tables required, is presented in the following tables, with the price of a day's work of the different classes of laborers, and the time of work—a day being 12 hours.

A Crible Shop Working 6 or 7 Full Months.

1 breaker or picker....1f. 50	1 sifter.................1f. 50
2 stampers............1f. 50 each	1 refiner at the German box..................1f. 50
1 washer............1f. 50	

Three Stamp-mills working 8 or 9 months.

6 stampers 1 f. 60 each; 2 for 24 hours in each mill.

Three Washing Shops for Same Time.

3 master washers	2 fr. each.
9 servants	1 fr. 10 to 1 f. 50 each.
8 children	0, 60 to 1 f. each.
6 laborers	1 fr. 30 to 1 f. 50 each.

Let us now examine in a general manner the products of the mechanical preparation, the entire treatment adopted at Vialas, its advantages and disadvantages. The numerous stoppages and intermissions of work at most of the apparatus, render impossible a reunion of all the corresponding products of different operations with certainty of a common origin. Unfortunately no assay either of raw materials or products is made at Vialas. We do not refer now to a great number of assays made on various products which do not always correspond; but among our results are some that allow us to appreciate the principal circumstances of the mechanical preparation;—these only we shall notice.

The excellence of the mechanical preparation depends on a large number of details, among which we shall notice only the nature of the ore, the expense of labor, but especially the loss in metallic matter, the importance of which often more than overbalances the economy in other respects from a more rapid operation. How often has the attempt been made in various districts of metallic mines to diminish the loss of useful substances; especially has the effort been made to diminish the slimy ore by more careful sortings; the loss of silver and lead increases elsewhere, and the first often more than the second, with the degree of the richness of the fine ground ore (schlich), and the washing of slimy matters has been pushed less far. Now, all these precautions will be so much more necessary at Vialas, as the ore is very rich in silver, and also in consequence of the circumstances of the metallurgical treatment; the loss at the foundry and at the roasting tends to increase with the richness of the schlich. Under all these considerations, it will be good to profit by the experience of others, and modify a little the mode of preparation, and even some of the apparatus.

In sorting, only two distinct classes are made, riddling and stamping sorts. The galena is very often disseminated in the ore, but in some veins more particularly than in others; certain ores have more quartz or barytes, others more slate. Whatever may be their nature, the ores are nevertheless mixed. The breaking which precedes the sorting is not pushed far enough. It results from this that the class called *stamp* contains often samples which a better sorting would give to the crible; for the latter, a more careful breaking and sorting would give more *massif*, especially if, aside from the general principles above mentioned, a lower standard was sought in the products sent to the foundry.

The following average assays better determine our appreciation:

The ore of the crible has yielded 30 to 60 per cent. of pig lead; we speak of the coarse ore.

The crible sand No. 2 and 3 have yielded by dry assay g6 — 0.50 per cent. of lead, and g7 — 37.50 per cent.,—on average 04 to 45 per cent. in pig lead of ore of the crible.

On the other side, 100 of the ore sent to the crible yielded—
25 fin sec., sifting No. 2 and No. 3 washed.
25 mud slime.
The remainder stuff to the stamps, pyrites, &c.
The *fin sec.* yields by dry assay 70.50 per cent. pig lead.
Sieves No. 2 and 3 washed—75 to 66 per cent.
The muddy ore (bourbes) 25 to 30 per cent.
Stamp stuff 15 to 20 per cent.

These results lead to the belief that the loss in metallic matter is very considerable in the treatment of ore as rich as that in the criblery. It is unquestionable that we gain very much by pursuing the breaking and sorting of the ore even of the cribles.

Of the stamp ore, some samples have yielded us in the dry way 25 to 30 per cent. of pig lead; in admitting a more feeble standard, we think one can draw from the ore a higher proportion of crible stuff. Even here the amount has been only 3-100ths of the whole weight of the ores treated.

(To be Continued.)

Art. II.—The Iron Manufacture of Great Britain—Theoretically and Practically Considered. By Wm. Truran, C. E. No. 9.

(Continued from page 140, Vol. 7.)

Section IX.—The Quality and Fusibility of the Crude Iron Dependent on the Structure of the Ore.

The very different action of the various ores of iron in the same furnace, under similar conditions of fuel and flux, as shown by their less or greater fusibility, and the degree of carbonization of the resulting metal, is a subject of paramount importance to the iron smelter.

Having witnessed the reduction of large quantities of ores of nearly every description, and noted the peculiarities bearing on the fusibility of the ore, and quality and fusibility of the resulting crude iron, presented by each in the blast furnace, we have concluded that the quality, measured by the quantity of carbon in combination, is directly dependent on the structural arrangement of the ore; and that the fusibility is dependent on similar causes, being greater or less according to the percentage of carbon combined.

It is known to intelligent smelters that in its descent in the blast furnace, the ore is deoxidated—the oxygen of the oxide of iron combining with gaseous carbon forming carbonic acid. In its further descent, the deoxidized metal combines with a greater

or less quantity of carbon from the ascending gaseous column, is fused, uniting with a minimum dose of carbon at the instant, and falls into the hearth. The entire quantity of carbon is absorbed prior to the descent of the metal into the lower hearth, for crude iron in the liquid form does not combine with carbon. The volume absorbed at the instant of fusion is inconsiderable; in our explanation it may safely be omitted; and the degree of carbonization calculated on the supposition that the entire volume is absorbed from the gaseous column by the metal while in the ore.

The velocity of descent of the solid column, and the period of exposure to the carbon of the gaseous column being alike, the volume combining will vary with the surface of metal presented for action. If the pieces of ore are large, and of a dense structure, impermeable to the gases, crude iron containing a minimum percentage of carbon, will be produced. The proportion of fuel to ore may be largely augmented, but under no circumstances will the quality of the resulting iron be otherwise than the lowest white.

With ores of similar structure, but of smaller dimensions, the volume of carbon will be augmented in the same ratio as the surface of metal exposed.

Ores of a high specific gravity, and yielding a large percentage of metal when in pieces of large dimensions, produce crude iron of the lowest quality; with smaller pieces the degree of carbonization is improved, but cannot be carried above an inferior white. On the other hand, ores of a low specific gravity, but yielding a high percentage of metal, when in pieces of a medium size, produce crude iron containing a maximum volume of carbon.

The richest hematites, and ores of a similar dense structure, produce iron having a minimum degree of carbonization; for in consequence of their high specific gravity, and the absence of volatile matters in their composition, a comparatively small surface of metal is presented to the action of the gaseous carbon of the ascending column. The quality is improved, when the surface is augmented by reducing the size of the ores to the lowest practicable limits, compatible with their complete reduction and the free action of the furnace. It may be further improved by reducing the velocities of the descending solid, and ascending gaseous columns. The volume of carbon combining, is inversely, as the velocities; hence, with diminished velocities the degree of carbonization is higher, but the weekly produce from the same furnace is reduced. On the continent, the production in charcoal furnaces of superior irons from rich ores of a dense structure, is accomplished by reducing their dimensions, and proportioning the velocities of the respective columns to the requirements of the case.

The superior quality of the crude iron smelted from the dense ores of certain continental districts, as compared with the iron obtained from similar ores smelted in this country, is generally considered as due to the different qualities of the fuels employed. While it must be conceded that the qualities of the fuel have an important bearing on that of the resulting iron, there is every reason to believe that the difference arises more from the mode of working the furnaces. Certain it is, that, when filled with ores of varying dimensions, and driven at the rate common in this country, the quality of the crude iron produced from the foreign charcoal furnaces is very little superior to that produced from coke and coal furnaces.

From the carbonates of the coal formations, iron of a superior quality may be smelted. The degree of carbonization varies with the composition of the ores. With those of the argillaceous class it is at a medium; but will be greater or less according to the percentage of metal and size of the pieces.

In the absence of other sources of information, the loss by calcination correctly indicates the fusibility of the ore; the volume of carbon taken up under similar conditions, and the fusibility of the resulting crude iron.

The production of a superior iron from the argillaceous ores is favored by the comparatively low percentage of metal, and by the large volume of gaseous matters distilled during calcination. The extended surface presented by the exterior of the ore facilitates the deoxidation; but when to this there is added the surface created by the distillation of its gaseous constituents, the facilities afforded for the absorption of carbon are immensely increased. During calcination they lose from 20 to 33 per cent. by weight of gaseous matters, principally carbonic acid, which renders the ore of an open, porous structure, permeable to the carbon of the ascending column; and at a low computation quintuples the surface available for deoxidation. Hence, the comparatively large absorption of carbon, and fusible character of the ore and resulting metal.

The degree of carbonization is carried farthest with ores of the carbonaceous class. Containing large quantities of carbonaceous matter, in addition to the carbonic acid common to all carbonates, these ores present after calcination, a maximum surface for deoxidation, and the absorption of carbon. The loss in the preparatory operation ranges from 28 to 60 per cent. The evolution of the latter quantity of gaseous matter has the effect of multiplying the surface at least twenty-fold. It is entirely owing to the volatile character of a moiety of its constituents, and the consequent porosity of the calcined ore, that the rapid deoxidation, and the large absorption of carbon is effected, as shown in the high velocity of the descending column, and the large volume of carbon combined with the metal.

The percentage in ores of this description is farther augmented by the larger space for the gaseous column, causing it to ascend with a reduced velocity, and to this extent facilitating the deoxidation in the superior regions of the furnace. The carbonates of the coal formations possess the exclusive property of augmenting the space, for, although the other ores may be reduced in their linear dimensions, so as to offer an equally large surface to the action of the gaseous column, they retain their original dense structure; and by filling up the interstices between the pieces of fuel and flux, contract the area, thereby augmenting the velocity of ascent, and diminishing the carbonization.

The fusibility of the respective ores is influenced in the same manner as the volume of carbon, by the surface of metal exposed to the action of the caloric and gases of the ascending column; but is modified to a certain extent by the quantity and character of the alloyed earths. With ores similarly alloyed, the degree of fusibility will be conversely as the volume of gaseous constituents; and inversely as the quantity of solid earthy matters.

The percentage of gaseous substances in the ore, by determining the volume of carbon in alloy, regulates the fusibility of the resulting crude iron. Various substances impart fluidity, but in this country carbon is the principal modifying ingredient. Irons containing a minimum volume are less fusible, and exhibit a marked deficiency of fluidity compared with those more abundantly supplied.

In extreme cases the quantity of carbon amounts to nearly 8 per cent. by weight of the alloy. At first sight it seems extraordinary that this percentage of carbon can be the cause of the great fluidity and low melting temperature of certain crude irons, especially those smelted from carbonaceous ores; but if the proportion is estimated by volume, it is seen, that, owing to the low specific gravity of carbon, it forms nearly 30 per cent. of the bulk; and since the fusibility is directly dependent on, and proportional with the volumes and melting temperatures of the repective ingredients forming the compound metal, the sufficiency of this large volume of carbon to produce those characteristics must be apparent. In crude irons sparingly supplied, say to the extent of 2¼ to 3 per cent., the carbon forms, by volume, from 9 to 12 per cent. of the mass. When remelted the larger portion is volatilised, and the fusibility and fluidity proportionately diminished. If again remelted, the deficiency of these properties is still further manifested: eventually, the most fusible iron having its carbon oxidized, becomes difficult of fusion and void of its former fluidity.

When thus remelted the loss of carbon by oxidation necessarily leaves the metal of greater purity at each successive fusion; and consequent on the deprivation of the constituent of least specific gravity, its density is largely augmented, so much so, that, even

while in the fluid state, it is greater than that of the cold unfused metal.*

Section X.—The Hot Blast.

Writers on the hot blast have greatly exaggerated the effect of this invention on the iron manufacture of this country. If we are to believe the majority of them, the great reductions which have been effected within the last 25 years in the quantities of fuel and flux to smelt a given weight of iron, and the large increase of make from the furnaces, is entirely owing to the use of this invention. Without here intending any disparagement to the hot blast, which unquestionably is a most meritorious invention, we must protest against this wholesale system of attributing to it powers which it does not possess. That the hot blast under certain circumstances has effected a saving in the consumption of fuel, and also augmented the weekly make, we freely admit. But the saving in fuel and increase of make due to its employment is not generally one fourth of the quantity which writers have asserted. A number have gone so far as to state, that, by the mere substitution of heated air for the cold air formerly used, a saving of two thirds of the coal formerly required for smelting a ton of pig iron was effected at the Scotch furnaces. Among them we notice the late Mr. Mushet. Before the adoption of the hot blast, the consumption of coal at the Clyde works in smelting, is given by that author as averaging 7 tons 3 cwts.

* The greater density of the molten metal is shown by the floating pieces of the cold metal only partially immersed. Numerous ingenious explanations of this apparently singular anomaly have appeared. Iron, like other substances, is expanded by heat, and in the molten state containing a maximum quantity of caloric, occupies a larger space than it does when subsequently solidified; therefore the specific gravity of the molten metal is inferior to that of the cold. But the fact of pieces of the latter floating in the former, with apparently considerable buoyancy, would seem to contradict this diminution of bulk and increase of specific gravity with the deprivation of caloric in cooling.

The late Mr. Mushet devoted one of his papers to this subject, but the conclusions which he adopted are manifestly incorrect. Unable to otherwise account for the phenomena, he assumed that cast iron possessed the greatest density when in the fluid state; that in passing from the fluid to the solid state it acquires its greatest volume, and that when cold and always in proportion to the absence of heat, so will be the diminution of bulk. In support of these assumptions he adduced the well-known fact of pieces of iron floating in fluid iron. A very simple expedient—ascertaining the specific gravity of the pieces, and also that of the molten metal when solidified—would have shown the fallacy of this proof, and demonstrated the fact that after allowing for expansion of volume by absorption of caloric, the molten iron must have been of much greater specific gravity than the unfused pieces. The subject appeared inexplicable to us until we discovered, that, with every remelting, the specific gravity of cast iron was augmented, with the first most rapidly, but with succeeding fusions to a certain extent, until the volume of carbon and other volatile substances were dissipated. By ascertaining also the specific gravities, we found that in no instance did pieces of iron possessing a superior specific gravity float on the fluid iron.

Now this appears to have been the consumption in the year 1797; for in another page we have, "Abstract of the quantity of materials required to manufacture one ton of pig iron at Clyde blast furnace No. 2 in 1797:

Coal for coking . . .	7	8	0	4
Ironstone, raw	8	1	2	0
Iron ore	0	2	0	0
Engine coals including coals for calcining	8	16	0	0
Limestone	0	17	1	4

And then to show the saving effected by a hot blast, we are presented with the consumption of materials to produce one ton of iron in 1839, as being:

Coals to the ton . . .	2	3	2	0
Mine, calcined	2	6	2	0
Limestone	0	11	2	0

Thus after a period of 42 years there is a reduction of 5 tons of fuel on the ton of pig iron. This saving is at once carried to the credit of the hot blast. With all deference to such an authority on metallurgy, we respectfully submit that the reduction of fuel due to the use of heated air is more like 5 cwts. than 5 tons. If this saving of 5 tons justly belongs to the use of heated air, we must draw the inference, that, in the 42 years between 1797 and 1839, the iron manufacture remained stationary, with the exception of the impetus given to it by this invention. And yet we know, that, during that period, numerous improvements were made in the preparation of the fuel and ore, in the furnaces, and in the blowing engines.

Were the invention universally applied to blast furnaces in this country, instead of to a moiety only, it would be difficult to show the saving due to hot blast, and that due to other improvements; but there are numerous furnaces to which it has never been applied, and the progressive improvement in these, within the period above mentioned, will enable us to approximate closely to the actual results. At the Dowlais furnaces in 1791, the ton of pig iron was made with the consumption of the following materials:

Coal for coking	6	6	0	0
Ironstone, calcined . . .	2	18	0	0
Engine coal . . .	1	15	0	0
Limestone	1	8	0	0

Forty years afterwards, namely, 1831, the hot blast having been some months in operation at the Clyde works in Scotland, the Dowlais furnaces were making one ton of foundry iron with the following consumption of materials:

Coal	2	10	0	0
Ironstone, calcined . . .	2	16	0	0
Engine coal	0	10	2	0
Coal for kilns . . .	0	6	2	0
Limestone	0	18	0	0

From this we learn, that the improvements in smelting have been such, that, with cold blast, a reduction of nearly two thirds of the quantity of coal required to smelt a ton of pig iron has been effected. When such results were commonly obtained, before the introduction of hot blast, in one of the largest works in Wales, with furnaces which have been blown with cold air without intermission since their erection, we may fairly conclude, that the immense saving of fuel so generally attributed to the use of heated air, is due to other causes over which it has only a very slight modifying influence.

The use of carbonaceous ore, which melts at a low temperature, and from its comparative freedom from earthy matters requires but a minimum dose of limestone for fluxing, has enabled the consumption of coal to be largely reduced. And by enlarging the throat of the furnace, the substitution of raw coal for coke was successfully effected, thereby enabling the consumption to be still farther reduced. Yet in nearly every notice of the manufacture, including that by Mr. Blackwell in his paper on the iron-making resources of the United Kingdom, so recently as 1852, the hot blast is credited as the cause of the diminished consumption of coal. The enlargement of the throat itself,—as we have shown in the case of one of the Dowlais cold blast furnaces, which from one third was enlarged to one half of the diameter of the furnace, followed by a reduction in the consumption of coal from 80 to 45 cwts.—accounts for one half of the reduction, without reference to the previous waste of carbon in the coking process,—a process which it was no longer necessary to continue with the larger throat. And in the Welsh district, cold blast furnaces when working entirely on carbonaceous ore, smelt with a consumption of fuel no greater than that used in the Scotch furnaces. Yet we frequently see it stated, that it is by the use of the hot blast the Scotch ironmasters are enabled to smelt their carbonaceous ores, and that, by its use also they are enabled to use their coals raw. If it is by the use of a hot blast that all this has been accomplished in Scotland, how are we to account for the Welsh ironmaster obtaining equally favorable results without its intervention?

The hot blast has also been credited as enabling anthracite coal to be successfully used as a fuel for smelting. The statement has been repeated by nearly every writer, as if the hot blast was more necessary to this coal than to others, notwithstanding, the now well-known fact, that this coal may be advantageously used in smelting with a cold blast of proper density, and that the iron so made is greatly superior to that smelted with a heated blast.

With an equal disregard respecting the correctness of the statement, writers have attributed to the hot blast the merit of augmenting the produce in a surprising manner. We award a superior make to the hot blast, but the increase does not usually exceed 12 per cent.

In 1791 the average weekly make of each of the Clyde furnaces appears to have been 17 tons. In 1839 with the advantage of a hot blast, but using argillaceous ores, the make was 52 tons weekly.

At the Dowlais furnaces in 1791 the average weekly make was 20 tons; in 1831 it had risen to 80 tons; and in 1839 to 91 tons, when working foundry iron. Cold blast being used through the whole period.

It is to the general use of carbonaceous ores that the comparatively large produce has been obtained from Scotch furnaces; were a cold blast substituted, the reduction of make through the change would not exceed the amount given.

The Scotch furnaces using a heated blast, and smelting carbonaceous ores yielding on an average 60 per cent. of metal, average 146 tons a week. Welsh cold blast furnaces smelting a much leaner, and more refractory ore, have averaged quite as much. Several of the cold blast furnaces at the Dowlais works make 170, and have exceeded 190 tons. The furnaces at the Plymouth and Duffryn works are all cold blast, yet they often exceed 180 tons a week. With these facts then before us, how much of the increase in the make of blast furnaces within the last 25 years can fairly be attributed to the hot blast?

HEATING HOT BLAST STOVES.

With a view of economizing the fuel consumed in heating the blast, stoves have been constructed, in which a portion of the heat generated by the combustion of the fuel within the furnace, has been applied to this purpose. The plan was extensively adopted at the Ystalyfera works, and lately has been applied at the Gartsherrie works. At the Ystalyfera works, flues were constructed from the furnaces to the stoves, which were placed at a suitable elevation between. To increase the draught and obtain a sufficiency of the heated products of combustion from the furnace, for communicating the necessary temperature, a lofty chimney was built to each stove, and furnished with a damper to regulate the draught.

By thus arranging the stoves, so as to heat the blast without the usual stove fire, a large saving of fuel was stated to have been effected"—"neither coal nor labor were required," and the working of the furnace was not at all interfered with." This is the statement of the proprietors, after they had had some experience of the working of the new mode of heating.

In reference to this plan of heating—and our remarks are equally applicable to other inventions of the kind—we would

ask: if the blast was heated without the intervention of coal, from what source did it obtain its caloric? We imagine that there can be no question but that it was derived from the coal consumed in the furnace. But then the difficulty arises: how was it that such quantities of caloric could be spared from the furnace without disturbing its operations? Simply, by filling in a larger quantity of coal than otherwise was necessary.

There is a great error committed by several patentees of improvements in iron-making which cannot be made too public. We frequently hear of the "waste heat' of furnaces, blast and others; and if a definition of the term is requested, it is found to embrace from eight to nine tenths of the caloric generated by the combustion of the fuel.* In each of the different furnaces employed in the manufacture, a certain quantity of fuel is consumed in generating the high temperature demanded; of the caloric evolved, by far the largest portion goes up the chimney, or otherwise escapes into the atmostphere,—this is generally considered as so much waste heat. But can the operations, with our present knowledge of combustion, be efficiently conducted without this waste? Unless they can, the caloric escaping into the atmosphere can no more be considered as waste, than the caloric from the chimneys of engine boilers, and a hundred other erections consuming coal fuel.

It is frequently observed by those who have not thoroughly studied the subject, and put the matter to the test of experiment in the large way,—"but this waste heat may be seized in its passage to the atmosphere and turned to profitable account." It is here that a great mistake is committed; for when the consumption of fuel is justly proportioned to the work to be done, no contrivance yet invented has ever enabled the ironmaster to turn this heat, or any part of it, to a profitable account, without impairing in a corresponding degree the efficiency of the fuel in such operation.

This mistake was committed in erecting the hot blast stoves at the Ystalyfera works. The heat for increasing the temperature of the blast, was abstracted from the furnace; and the quantity which would under ordinary circumstances have been consumed in the stove grates, was now added to the consumption of the fur-

* Literally, the entire quantity of caloric evolved by the fuel in every operation of the manufacture, is wasted by escaping into the atmosphere. The caloric evolved in the blast furnace escapes in union with the gaseous column at top, and the liquid products at bottom. The quantity escaping with the former is usually considered as wasted, but the quantity in union with the metal and cinder—probably the largest portion,—is equally so much waste, and deserving of being economized. But while numerous contrivances have been devised for economizing the minor quantity united with the gases, all causing a greater or less disturbance of the smelting operations, no attempts have been made to utilize the caloric evolved by the escaped metal and cinder in cooling down to the temperature of the surrounding media, though the utilization of such caloric, could in no wise interfere with the working operations of the furnace.

nace. If the yield of coal in the furnace, previously, had been unnecessarily large, sufficient caloric could be spared for this purpose without greatly impairing the carbonating power of the fuel, but if otherwise, the consumption must have been largely increased.

In the case of these furnaces, the caloric was abstracted at a depth of about 5 feet from the top, or one fifth of the height of the furnace at that period. At this depth, the tall chimney erected to obtain the requisite heat on the stoves, added to the pressure of the ascending column, caused such an indraught, that, besides depriving the coal of a portion of its carbonating power, the absence of the usual column of gases in the materials above the flues, largely diminished the smelting power of the furnace. After a period the height of the furnaces was augmented nearly one half, but the disadvantages of this mode of heating were still apparent. That no saving of fuel really occurred in practice we are justified in stating, from the circumstance, that, after a lengthy trial, the plan of absorbing heat from the materials was abandoned, and other means for heating the stoves adopted. It is very probable that the consumption of coal in the blast furnace was augmented in a greater ratio than the saving in the stoves.

In the sections on bar iron, we purpose drawing the attention of the ironmaster to somewhat analogous instances of a supposed saving of fuel in the mill and forge operations, but which in reality involve a larger consumption.

WATER BLOCKS.

In previous sections mention has been made of water blocks, breasts, and other contrivances for keeping the brickwork around the tuyeres and cinder-fall at a low temperature. The necessity for these contrivances has arisen with the wide hearth and numerous tuyeres blowing into the same. With the old narrow hearth, the blast penetrated to the opposite side, but the enlargement without a corresponding increase in the density of the blast, has resulted in the production of a greater temperature immediately at the tuyeres, at the expense of the other portions; this evil in numerous instances has been aggravated by the substitution of two, and three pipes, for the single pipe formerly in each tuyere house. Hence, a scattered blast creating an intense heat in the immediate vicinity of the tuyere, to the rapid destruction of the brickwork.

The water blocks and breasts were designed as a remedy for this burning of the brickwork, and wherever applied, appear to have been very successful. But it is a question if the saving in brickwork by their employment is not more than balanced by the larger consumption of coal.

By experiments we find, that the quantity of water passing through the various tuyeres, blocks, &c. of a furnace, averaged 17 gallons per minute. The temperature on entering was 45°, and on

escaping 135°. Now, to raise the temperature of this quantity of water 90 degrees, requires an expenditure of rather more than r½lb. of coal. The weekly expenditure calculated at the same rate will be nearly 7 tons.

This consumption of coal is not readily seen, but undoubtedly it is going on. The coolness of the breasts and tuyeres, is caused by the water absorbing a portion of the caloric evolved during the combustion of the coal, which is thus lost to the operations of the furnace.

The weekly cost of these cooling contrivances, in loss of fuel, being ascertained and added to their first cost, and the expense of keeping them in an efficient working state, a comparison may be made with the expenses usually incurred with brickwork; the balance, we anticipate, will, in nearly every case be largely in favor of the latter.

The application of water breasts, certainly evince much ingenuity, but the evils of an intense local heat remain in full force, and are to be removed only by proportioning the density and volume of the blast, to the size of the hearth and smelting power of the furnace. By attention to these points, the breast may be kept comparatively cool, and a full weekly make with a minimum consumption of fuel insured.

ART. III.—AMERICAN SCHOOL OF MINES.

In a recent number of this Magazine there was published a letter on the subject of an "American School of Mines" from the pen of Mr. R. G. Rankin, of this city. We were about to pursue the same subject further in these pages, when the same gentleman addressed to us another communication expressing fully his views on this important organization, which so entirely concur with our own sentiments, that it affords us much pleasure to present his remarks in place of any by ourselves. Mr. Rankin proceeds as follows:—

Permit me to expand the thoughts heretofore suggested. It will be remembered that some three or four years ago an immense number of mining companies were formed and mining enterprises projected, the very name and recollection of which is now only tolerated or alluded to because suggestive of lessons of dear-bought wisdom. These companies are associated with unfounded expectations, overwrought descriptions, and calculations *as fallacious as figures* (notwithstanding it is said figures will not lie), the natural consequences of *the great ignorance prevalent throughout our country on the subject of practical and economic mining.* It is safe to say that if a tithe of the money so inexpertly expended had been applied to the establishment of a school of mines, the country would have been richer by millions; not only by the amount of positive loss saved, but by the amount that might have accrued in profits and augmented values to our whole mineral economics.

The organization of such a school of mines was the subject of much conversation among the delegates, at the late meeting of

the *American Association for the Advancement of Science* at Albany. Its necessity was unanimously conceded by all those who expressed any opinion, and the only point of difference was as to the extent and scope of its initial movement.

Its foundation upon a scale commensurate with its importance and the development of our mineral wealth, and with a range and grade of pursuits in the departments of Geology, Natural History and Physics, similar (*mutatis mutandis*) to the European schools of mines generally, was admitted to be the best and must ultimately be *the only true foundation.*

But it should be remembered that such institutions do not spring up full armed—full fledged like classic mentors from cerebral embryonics of modern Jupiters. These invaluable European schools had moderate beginnings, an ovicular germ, and by progressive developments have attained their present structural organization. Science in the exercise of its legitimate functions, put forth its great laws of adaptation and adjustment, and fitted these schools to the growth and mineral developments of the respective countries. They grew with society and its requirements, and will continue so to do only with accelerated velocity from already acquired momentum. And so, I apprehend, it must and will be with our *American School of Mines.* Its foundation—its initial movement must be practical and adaptive. If its first movement is only to establish a *Repository* for the collection of our American Economic Mineralogy: plans of mines; models of mines and mineral basins and deposits; geological sections of valleys; orographic models in wood or plastic materials; the names, uses, descriptions, of tools and implements used in mining; drawings showing the laws of shafting, drifting, ventilating, upcast and downcast workings, &c., and many other associated requisites; if such a repository is obtained, something will have been done towards the great object in view. Such a beginning, humble although it may be, is believed to be the true one, especially when connected with a *library* of mining works and authors located at the Repository.

In the Repository should be found the crude or natural clays of which our bricks are *or may* be made. Our carbonates and sulphates of lime and various limestones in the rough and polished state (many readers will remember the variety in the Washington Monument)—all showing marbles unsurpassed in any other country—should have their prominent positions.

It is believed that *our* clays, kaolins, marbles, slates, &c., afford materials for encaustic tiles, tesseræ, guilloche work, mosaics, tessellated pavements, pottery, porcelains, water bottoms, floors, &c., equal to any other formations of the other continents, and will compare favorably with any ancient Berytus.

Our sandstones, embracing *scores* of varieties, and equal to any in the world, have their place in connection with their practical uses in the arts and requirements of our American life. The

kinds—component parts—comparative utility and durability of our granites—could be ascertained at a glance.

The sands and materials used in the manufacture of glass would have their appropriate collocation, and the visitor would be apprised of the interesting fact, that the best glass in Europe is made in part from materials exported from the United States.

In its appropriate place we should find the *Fossilogy* of our State (and in turn of our country) the best defined of any geological system thus far known. The order and elements of our geological eras illustrated by appropriate models, would do more to impress the observer or student of geology with a *true idea* of the subject than months of study from books only.

The *Metallurgical department*, with its specimens of crude minerals, and exhibiting the order and process of manufacture, each condition of its reduction and change from raw material to the manufactured article, would probably be *the interesting* one to the *early realizing* eye of American mineral owners.

In connection with this Repository and Library, arrangements should be made for lectures on *the practice* (I do not as yet call it the science) of mining.

Such an organization might be made in connection with some existing institution, having a corp of professors devoted to a course similar to the *scientific course* of the University or the Free Academy. The professor of the art of mining should at first draw his remuneration from the attendants upon his lectures. It is true such a professorship would be no sinecure, and its duties would only be discharged by a devotee of abstract or applied science.

Perhaps it may be said by some readers that the endowment of such a professorship would be no difficult matter in a community where so many mining interests are concentrated, and we coincide in the opinion; but would it not be better to take the amount of such an endowment (say $25,000), and expend it in the establishment of the *Repository and Library* before alluded to, and the *importation* from the best of European mines and schools of the most improved and best developed models of mines, and *in the manufactures at home* of wooden or composition models of our whole American geology and geodesy. It is believed that some such arrangement might, and should be, made with some of our city (instead of country) institutions, for the reason that a large portion of the mineral and mining interests of the country are represented in our city. To say nothing of the centralizing power of capital and wealth, science and arts in our city, we have good examples in the European world for the establishment of such an institution in the city instead of the country.

The present condition of science in France is materially due to the "Institute of France," and from it have sprung as collaborators the numerous town and communal societies and organizations for the diffusion of scientific knowledge. So has it been in England, where London is the focal point for the applied sciences

and their profitable sequences, while all over the realm the abstract sciences have found their local habitations even without sequential profits.

The geological surveys of the several States have developed an immense treasure of mineral wealth. Twenty-four or five States have to a greater or less extent engaged in, or are now prosecuting such explorations, and a corp of over seventy of our ablest Geologists and savans has been, or is now engaged in this work of discovery. But *cui bono?* for whom and to whom does all this labor enure? whose is the practical benefit of these mineral values —these geological developments? It may be safely answered that thus far the dealers in mining stocks and shares have been the principal gainers. Scores of valuable mining properties are now tied up in the complications of incorporated stock operations and *dissolutions*, which properties, if mined properly, would give large additions to our native mineral wealth. In most of these cases more has been expected from profitable returns of sales of stock, than from sales of ores or metals. It is said, and no doubt with truth, that more capital is annually wasted or lost by unprofitable or ignorant systems of mining, than would *recapitalize* the whole iron interests of the United States.

It is almost a daily question in Wall Street, where can one go to procure some reliable information about the *cost*, *mode*, and *profits* of mining? Where can one go and read and study and apply his own common sense, enlightened by the practical and experimental knowledge of others, to his own particular case or property? Where can abstract scientific knowledge find its application? Where can wisdom and knowledge be derived from the practice and labors of others?

Such a Repository and Library and Professorship as has been already suggested, would be one step towards the acquisition of such practical knowledge. This step would lead to others—the nucleus would grow by gradual accretions—the molecule would become the beautiful crystal, and in time we should have OUR schools of mines, with thousands of students—OUR professorships of metallurgy, geology, mineralogy, organic and analytic chemistry, and cognate branches; we should have our halls of mines and models of the internal structure of hills and deposits; orographic and stratigraphic sections, all turning mother earth inside out for our supervision, and telling us in a word the whole story of an investment in its inception, progress and results. Upheavals and subsidences, erosions and denudations, dikes, faults, and elvans, all will be made apparent and appreciable to the common sense of observant minds, and we shall no longer hear (as has been actully witnessed within a few weeks) of a large and wealthy company determining their shafts, drainage, and breastworks by the *strike*, and their adits and levels by the *dip* of their mineral vein.

Let it be remembered that mining exploration has produced some of the highest efforts of human skill in mechanical philosophy,

and involved a system of subterranean architecture which has few if any parallelisms upon the surface of our earth. Take for example the works in the Rörerbühel mines. These mines were worked to the depth (according to Humboldt, Cosmos, vol. I., page 159) of 3,107 feet, and this great depth of excavation was attained in the sixteenth century, and before the reputed modern? invention of gunpowder, and *plans of these works are yet preserved.* The old Kuttenberger mines of Bohemia are 3,778 feet deep, the greatest known depth of any mine. There are mines in Cornwall, England, of the depth of 1,300, 1,600, and 1,650 feet. The *engine shaft* of the Consolidated Mines is 1,650 feet deep, and the total length of adits, shafts, galleries, sixty-three miles. The adit for the discharge of water from the Gwenap mines is thirty miles in length. The silver mine of Valenciana in Mexico is 1,860 feet in depth. Unaccustomed as we in this country are to realize such wondrous underground works, it may seem still more surprising that models in wood, leather, plaster, sulphur (and of late india-rubber and gutta-percha), or drawings are to be found showing to the eye a pictorial and graphic representation of the whole underground operation.

The theory of veins also involves points of the highest interest, and models and graphical delineations of them would save many dollars to the farmers' pockets.

Their productiveness is measurably influenced by their associated rocks, and when an unscientific man is told that in hard or crystalline rocks his vein will be pinched up and thin; that in spongy or porous rocks it is less well defined and is diffused; that veins generally are more productive in some hard and decomposed granites; that veins in the granites deteriorate as they pass into the slates and conglomerates; when he is told and showed further that there are veins of injection and crystallization; veins of sublimation and condensation, and probably veins of electro-chemical precipitation from aqueous solution, and is shown in the laboratory and lecture-room how such things are to be apprehended, it is reasonable to suppose that in our country, as elsewhere, practical knowledge and pecuniary profit will go *pari passu.*

It is not *Americanizing* too much to say that the mineral wealth of the United States exceeds that of any other country. The native mineral wealth of Virginia alone exceeds the half of Europe, and yet for want of proper mining we are dependent on foreign lands for the most of our valuable metals. In some instances ores of argentiferous galenas are taken to Europe, the silver extracted and the marketable lead returned to us at full market price. The art of mining in addition to its legitimate fruits and benefits, has done much to develope other arts, particularly typography and engraving. Some of the most beautiful specimens of the bibliographic art have been devoted to mines and kindred subjects. These brief and palpable suggestions on this interesting subject

are submitted to your readers, with the announcement that a number of gentlemen of similar views are preparing a *modus operandi* for such a beginning of the American School of Mines.

ROBERT G. RANKIN.

ART IV.—VISIT TO THE LAKE SUPERIOR REGION, IN 1854.*—By Prof. L. E. RIVOT, of the French School of Mines. No. 5.

[Continued from page 418, Vol. VI.]

THE trap certainly extends a great distance westward into the State of Wisconsin, and the excursions which have been made there by hardy explorers have determined the existence of deposits of native copper, well beyond the limits of Michigan. It will not be until quite a future day when the miner will advance westward, for the facilities of sustenance and transportation will be more unfavorable than at Keweenaw Point, or in the Portage and Ontonagon regions.

The conglomerates present themselves in very powerful beds on two sides of the trap, but their thickness will not compare with the great zone observed near Agate Harbor and Copper Harbor. It should not be concluded, however, that there actually is less of the conglomerate in the Ontonagon region than at Keweenaw Point; the alluvium covers too vast an extent to allow it to be possible to determine any thing in this respect.

The conglomerates have not as yet been noted between Portage Lake and the Algonquin mine; between this mine and the Douglass Houghton the beds are very powerful from east to west; there the trap runs N. 25° E. and S. 25° W., and the axis of elevation is nearly in the middle of the zone of trap.

More to the west the direction of the trap is almost parallel to the coast; the chain of mountains, from a double slope, is nearer the southern limit of the trap; the conglomerates appear in beds which are more powerful at the north than the south.

I shall show further on that the deposition of the sedimentary beds can be explained by the obliquity of the fracture produced by the upheaval in the series of trap, conglomerate and sandstone.

The sandstone presents in the Ontonagon region a vast development, and forms on two sides of the trap two belts, the larger of which exceeds at many points 25 and even 30 kilometres. The one on the north extends to the borders of the lake, the other on the south is bounded by the metamorphic rocks and by the granite and trap.

The sandstone on the north is mostly covered by alluvium, and its deposit is not apparent, except at a certain number of points. It is generally colored red by the oxide of iron, but many beds are almost white, and their alternation produces on a small scale the curious effect of the pictured rocks. At the point of contact with the trap and conglomerate, the sandstone extends towards the north-west under a very variable angle, but always nearly equal to the angle of inclination of the trap-belts. Near the

shore, their slope is, on the contrary, very small, from 4° to 10°, and any one will admit that the beds of sandstone possess a much smaller inclination, as they are farther from the trap zone.

Around the Porcupine Mountains, the sandstone is broken, and rests on all sides, upon the jasper at the south, and the trap at the west, north and east.

The sandstones at the south present an analogous disposition; their beds are inclined to the point of contact with the trap, becoming sensibly horizontal at a certain distance, and elevating themselves anew, and presenting an inverse inclination around the metamorphic rocks, the granite and trap which bound them on the south.

At the west, the sandstone terminates at a point upon the trap; its fractures and inclinations show that it has been elevated on two sides.

In many places the sandstone forms isolated mountains, and dislocated beds dip towards all the points of the horizon, which appearance can be explained by the supposition of a local upheaval, the intensity of which has not been sufficient to bring up the trap.

This explanation is rendered plausible by the existence of isolated mountains of trap, the beds of which dip in the same manner towards all points of the horizon, and upon which the beds of sandstone rest on all sides. The most remarkable point is the *silver mountain* shown on the chart of Messrs. Foster and Whitney.

During the numerous excursions which the preparation of the geological chart has required, the existence of many strips* —of magnesian limestone reposing upon the horizontal sandstone has been established. They are broken and dislocated, but present the greatest analogy to the limestone extending from the west of Saut St. Mary—upon the belt of strata which separates Lake Superior from Lake Michigan.

The existence of the magnesian limestone south of the trap is a fact of the greatest importance, for it proves the identity of the sandstone which exists north and south of the trap with that which forms the southern border, or the south, and the violence of the derangement which has been caused by the upheaval of the trap, conglomerate and sandstone.

It demonstrates likewise that the elevation did not occur until after the deposit of the limestone, that is to say, after the lower silurian epoch.

The Isle Royal.—The Isle Royal is situated in front of Keewenaw point, at such a short distance, that in fine weather the mountains of Copper Falls can be seen. It extends in the direction of N. 65°, E. to S. 65° W.; its length exceeds 75 kilometres, whilst its greatest breadth is less than 14,000 metres.

On the north-east it presents three deep bays separated by

* One of these is found twenty kilometres west of the foot of the bay of Keweenaw.

parallel mountains, which make their form compare with the fingers of the hand.

In the bays the water is very deep, principally on the south side, and vessels can there obtain a refuge from tempests. The most important port in this part of the isle is Rock Harbor; on its border the Siskawit Mining Company has commenced working on a vein of copper which appears at present to be of doubtful richness.

The southern side is somewhat broken, and presents throughout its whole extent dangerous places.

On the south-west the shore presents many well-sheltered bays; that of Washington Harbor could be transformed into a magnificent port if this part of the country was inhabited.

Upon the southern side the immense bay of Siskawit in the sandstone and conglomerate can contain whole fleets.

Isle Royal is almost entirely composed of trap and presents no conglomerates and sandstone except on its southern extremity.

The surface of the ground is very broken, but all presents a general arrangement which is very simple and easy to be comprehended; the different varieties of trap, the compact, granular, amgydaloid, in very powerful beds, separated by seams of sandstone and conglomerate, form mountains strictly parallel to the general direction of the island, and elevated 150 to 200 metres above the level of the lake.

On the north, their sides are steep; on the south, on the contrary, their slopes are very gentle and variable—like the inclination of the beds, 10 to 12° S. E.

The conglomerates abut upon the trap, and their beds dip likewise towards the S. E. at an angle of 10 to 12°; they are covered by sandstone of the same inclination.

In comparing this arrangement with that of Point Keweenaw, it is impossible not to recognize the identity of the two series; on the south we can well distinguish the line of the Bohemian Mountains, according to which the upheaval has taken place; at Isle Royal, we can admit, by reason of the small inclination of the beds, that the upheaval has been produced by the granite, which appears in the mountains on the Canada side.

SECTION II.—DESCRIPTION OF ROCKS.

In the preceding chapter I have rapidly passed over the characters of the different rocks, in order not to complicate the exploration of the arrangement of the series. It is important to review these interesting details before commencing a description of the deposits of copper.

I can speak only of the rocks, which are formed in the Ontonagon region and at Point Keweenaw, the two parts which are the most interesting, by reason of the richness of the mines of copper, and the progress of mining there during the last few years.

The trap forms beds which are very different from each other

in their appearance and structure. The rock appears to be a more or less intimate mixture of amphibolic hornblende and Labrador feldspar; these minerals are sometimes in distinct crystals, sometimes in imperceptible grains.

The chlorite and the oxide of iron enter almost always in marked proportions into the composition of the trap, and in the cavities we frequently find very beautiful crystals of prehnite, epidote, &c.

The chlorite is often in such strong proportions that the trap appears to be a mixture of feldspar and chlorite, containing a very little of (amphibole).

The oxide of iron is almost always in small discernible crystals; sometimes, however, they cannot be distinguished by the eye; but their presence is always detected by the energetic action produced on the magnetic needle. Sometimes the needle of the compass deviates many degrees from its true position; sometimes it rapidly oscillates from one side to the other.

This action on the compass is extremely embarrassing—whether in use for laying out the plans of mines or directing in forests. It changes from one bed of trap to another, and the study of these variations as compared to the richness of the veins worked yields interesting results. Electricity has certainly played a great part in the deposits of copper in a native state, and the conductibility of the trap should be in relation with the action that rock exercises even now upon the compass.

Green epidote, more or less mixed with quartz or limestone, presents itself in considerable masses among the beds of trap and penetrates a great distance in the amygdaloid rock; the fact has not as yet been observed at Point Keweenaw, but it is of frequent occurrence in the Portage region and the Ontonagon.

The defined crystals of epidote and prehnite have a relation with the veins which traverse the trap; they have been more frequently met with at Point Keweenaw than elsewhere, probably because in that part of the country the series has been much more broken by fissures in the upheaval.

In structure the beds of trap present numerous varieties. Some beds are compact, very hard, and highly charged with amphibole; others have a granular texture, and contain much feldspar visible in white and red crystals; they are as hard as the first, and are not regarded as exercising a good influence upon the richness of the veins. This opinion is perhaps unfounded, and proves only the want of success in a small number of trials made in that rock. I will show in the next chapter that the veins are extremely numerous, but that very few of them are rich in copper. We should not lay down a general rule on the subject of trap of a granular texture before the influence of that rock has been established in many productive veins.

The most remarkable variety of trap is that called amygdaloid. It is eminently metalliferous, that is to say, it contains the

richest part of the productive veins explored at the present time. In general its color is high—it acts strongly on the magnetic needle, and presents numerous round cavities communicating with each other by almost imperceptible fissures filled by various minerals.

It is a finely fissured rock, disposed in more irregular beds than the other varieties of trap, and comparable in texture to a paste of slag rapidly congealed. The minerals which fill the cavities are vitreous quartz, agate, feldspar, white spathic, limestone, fibrous and radiated chlorite, epidote, prehnite, analcimine and native copper.

Every bed of amygdaloid has its peculiar minerals. At Keweenaw Point, at the north and south of the greenstone, the nodules are principally formed of chlorite, quartz and feldspar; in the middle of the metalliferous zone of the north, a bed of amygdaloid has been penetrated by the stuff of the neighboring veins; the cores are composed of quartz, limestone, chlorite and native copper. The Copper Falls has been tested and its standard of copper is quite high, giving promise of very profitable results.

Around the Portage and in the Ontonagon region the amygdaloid is penetrated by the epidote, limestone quartz, and chlorite; the native copper presents itself only in the immediate neighborhood of the veins. In the nodules containing copper, we notice that the metal often forms a very fine pellicle enveloped in chlorite and limestone.

Agate is formed not only in the nodules in amygdaloid, but it often presents itself in little veins and nests, which recall in a striking manner, though on a small scale, the celebrated deposits of Oberstein. The amygdaloid belt near the shore of Agate Harbor, is the ore which appears to contain the most beautiful agates; the bay derives its name from that circumstance which was observed by the first explorers.

The greenstone is a trap of a crystalline texture containing much amphibole and chlorite; the color of the rock is more or less deep according to the proportion of feldspar.

The porphyritic trap of the Bohemian Mountains contains very pure crystals of feldspar, imbedded in matter of a high color, which is crystalline, and contains much amphibole. The rock becomes sienite when the crystals of feldspar are very numerous and contiguous.

The jasper appears to be a feldspatic sandstone subsequently subjected to the action of a high temperature; it is accompanied by porphyritic trap at Mount Houghton and the Porcupine Mountains. It is superincumbent on the trap in the Ontonagon region.

The conglomerates contain round pebbles of all sizes of compact, amygdaloid, crystalline and porphyritic trap, and of jasper, that is to say, of all the other hard rocks but granite existing in

the country; they are imbedded in compact cement which seems to be composed of the same materials. The secondary sandstones of which the beds are comprised in the formation of the conglomerates are formed of grains of quartz and feldspar in a ferruginous cement.

Upon examining carefully the round pebbles of the conglomerates, we detect very fine fissures full of spathic limestone, which appears also to exist in the cement. They indicate a phenomenon posterior to the formation of the sedimentary strata, probably contemporaneous to the injection of the veins.

The sandstones cover the greatest portion of the country, and form almost the entire coast (*côte*) beyond St. Mary's to the massive granite, and from Portage Lake to the foot of the lake. An immense strip presents itself besides, between the trap and the granite, of the bay of Bête-Gris even to Black River. The arrangement of the beds and their appearance leave no doubt of the identity of the sandstones in the different parts; it is primitively deposited upon in horizontal beds upon all the country, above the rocks which have especially the texture of conglomerated trap.

The beds of sandstone, red more or less deeply, and those approaching the conglomerate are very highly charged with oxide of iron; the upper beds are slightly covered, and the cement becomes limestone for those immediately below to the magnesian limestone.

The grains are almost always quartz and feldspar; the cement is ferruginous, and resembles a sediment of an argillaceous consistence, such as would admit of the disintegation and partial decomposition of the amphibolic rocks. The beds which are slightly colored and white have a very feeble consistence and contain very little or no cement, except in the upper parts of the formation, in which the cement is calcareous.

No fossils have been found in the conglomerates or sandstones, and their age cannot be determined except by their position below the magnesian limestones which belong to the lower silurian period.

From the eastern extremity of Point Keweenaw to the Albion mine, near which the greenstone ceases to appear, the series of trap, conglomerate and sandstone present numerous fissures which are almost vertical and always sensibly normal to the direction of the seams. They are more numerous and more marked in the trap than in the sedimentary series; they can be seen principally in the greenstone on the southern declivity, which presents a section of the series well exposed.

In the sandstone the fissures are not so strictly normal to the strata, and preserve their parallelism over a vast extent. In the conglomerate we distinguish rather grand fractures than true fissures.

In the Portage and Ontonagon regions, the trap is not so

broken by fissures as in the eastern part of the point. It appears there to have experienced a removal of successive beds one after the other; at the same time vast breaks are indicated by the transverse valleys. The sandstones present besides some systems of parallel fissures almost vertical but very removed from each other.

The magnesian limestone is found only at some points west of the Keweenaw Bay reposing upon white sandstones; it is of no importance except in a geological view, as a proof of the identity of the sandstones of the metalliferous district with those upon which repose the magnesian limestones at the west of St. Mary's.

(To be continued.)

ART. V.—THE IRON DEPOSITS OF NEW YORK STATE. By J. D. WHITNEY.

THE deposits of iron ore in New York are on the most extensive scale and of the most varied character.

In the eastern part of the State, in Columbia and Dutchess Counties, hematite ores occur in extensive and valuable deposits, being similar in character and adjacent to those occurring in Massachusetts and Connecticut. There were, in 1849, seven furnaces using these ores. According to Professor Beck, there are several important beds. That of Fishkill is mentioned as occurring in a hill, near the junction of mica slate with the gray and white limestone. The Clove ore-bed is an extensive deposit of brown hematite in the south-western part of the town of Union Vale. The Foss ore-bed is of less importance, but similar to the one last mentioned. The Amenia bed is one of the most important in this region, and has yielded a large amount of ore, and, according to Professor Mather, will continue to do so for many years to come. A layer of broken rocks and gravel covers the ore to a depth of from five to twenty feet, and the ore-bed beneath had in 1838 been worked to a depth of forty-five feet without its bottom having been found. The amount furnished by this bed is estimated at 5,000 tons per annum, yielding fifty per cent. of pig iron. Prescott's ore-bed is in Columbia County, in the town of Hillsdale. It seems to be similar in position, as well as in the quality of the ore furnished by it, to the one just described. The quantity is also very large, as the bed has been penetrated to a depth of thirty-two feet, and the ore found to improve in quality, and to continue still farther.

The belt of metamorphic rocks which passes through the south-eastern corner of the State, and is developed principally in Putnam, Orange, and Westchester Counties, contains very numerous deposits of magnetic iron ore, but which appear to have been, at least until quite recently, very much neglected. Prof. Beck remarks of the ores of Orange County, that "it is doubtful wheth-

er the quantity (of the magnetic oxide of iron) which exists here does not exceed that found in an equal area in any part of the world." In 1849 there were only two furnaces using these ores, although another was built, and ready to commence operations when the price of iron should rise. It is difficult to see what drawback there can be to the future prosperity of this region, situated, as it is, so near to the metropolis of the country. Among the important deposits of ore, the following are mentioned by Prof. Beck: Sterling Mountain, in the town of Monroe; the ore is granular magnetic oxide, containing some pyrites. This deposit was opened in 1750, and a blast furnace built near it during the next year. The Belcher Mine, 1½ miles south-west of the Sterling Mine, has been worked over a width of 115 feet, without finding the wall-rock. Crossway Mine; a bed fourteen feet thick, which has been mined to some extent, making a moderately good red-short iron. Patterson Mine; the ore from this locality contains considerable silica; the iron produced from it was of a good quality, the ore yielding about 56 per cent. in the furnace. Forshee Mine yields a very good ore, which is abundant. Forest of Dean Mine, six miles west-north-west of Fort Montgomery; according to Mr. Hodge, a vein of magnetic ore, from 10 to 16 feet wide, of good quality, and well situated for working.

It would be impossible to enumerate all the localities known to exist in this part; and it is not easy to understand why they have not been more extensively worked. Recently, it is said, operations have been commenced here on a somewhat more extensive scale than previously, but I have not the particulars of what is now doing.

The great azoic region of New York, which occupies the larger portion of the northern part of the State extending from Lake Champlain to Lake Ontario, is exceedingly rich in the specular and magnetic ores of iron.

It would be vain to attempt to state all the localities where these deposits exist, but some of the most important may be specified. The counties where they are most developed, or best known, are Essex and Clinton. St. Lawrence also contains some very valuable mines. Those of Franklin and Jefferson Counties are of less importance.

The iron ores of this region have been described by Prof. Emmons and Prof. Beck in their official reports, and also, partially, by Mr. Hodge.

The ores of Clinton County are among the most celebrated in the country. They are all in masses intercalated in the gneisoidal rocks, and coinciding with them in their line of strike, but not always in their apparent plane of dip. The Arnold Veins are best known. They are four in number, of which one, the "Old Blue Vein," is considered of great value on account of the purity of its ores. This varies from two to eight feet in width, and in 1842 had been worked to a depth of 260 feet, and over a length of about 80 rods. The ore of this vein, according to Prof. Beck's

analysis, consists of nearly pure magnetic oxide of iron, with a small percentage of silicious matter. The four veins are parallel with each other, and have all been heaved simultaneously by trap-dykes which intersect them.

The Palmer Vein is a bunch of magnetic iron ore 35 feet wide, without any distinct walls, but gradually passing into the adjacent rock. The ore is much mixed with quartz, and requires washing before being worked. The Cook Veins are four or more in number, of which the widest is 14 feet across. They dip nearly perpendicularly, with the rock. The ore is said by Prof. Emmons, to make iron of the first quality for toughness. The principal vein has been traced for 1¼ miles. The winter bed appears in the form of a thick plate, overspreading several square yards of the rock with which it is associated. According to Dr. Emmons, "it appears as if deposited horizontally on the rocks, like an overflowing melted mass of lava."

In 1849, the largest bloomery in the country was engaged in working these ores. It had 21 fires, and one oven for reheating the blooms. The bar iron produced is said to be much valued for nails. Mr. Hodge remarks of the forges in this and the adjoining county, that their business is very extensive, requiring about 50,000 tons of ore a year to supply their demands. The blooms and bar iron made by them will bear the high cost of transportation, which pig iron would not do. Besides, it is generally believed that these ores work better in the bloomery fire than in the blast furnace.

The ores of Essex County are not less valuable than those of Clinton. Port Henry is the head-quarters of the iron manufacture of this district. Among the most important iron-producing localities are the Cheever Mine, the Sanford Vein, the Penfield Vein, &c. The Cheever Veins are two in number, one of which is six feet, and the other from eight to ten in thickness. The ore is a very pure magnetic oxide, of rather coarse grain. The cost of mining and conveying the ore to the furnaces on the Lake, in 1849, was about 80 cents. A deep adit has been driven in from near the Lake, which will afford access to many hundred thousand tons of ore.

The Sanford Vein is about four miles north-west of Port Henry. This ore is remarkable for its coarsely crystalline texture, and for containing considerable phosphate of lime mixed with it. Its masses are very large, so that it may be easily and cheaply mined. It works easily in the blast furnace, but is not adapted for the bloomery.

The other and more remote parts of the county contain numerous deposits of ore, many of which are of great extent, but they have been but little worked. The cost of manufacturing pig iron in this region in 1849, was about $20 per ton; the cost of the ore being estimated at $2 per ton, and of charcoal at 6 cents per bushel, which was the price usually paid.

The ores of St. Lawrence County are chiefly the specular. One of the most important localities is the Parish Mine in Governeur. From an analysis of this ore by Prof. Beck, it appears that it is almost pure peroxide of iron, containing only two or three per cent of silicious matter. The deposit of ore is represented by him as a flat bed, between the gneis and the Potsdam sandstone; but according to Prof. Emmons, it appears to have the character of an eruptive mass, which has lifted up the strata of the sandstone, and caused them to dip each way from the igneous nucleus. The Tate and Polley Veins are also mentioned by the State Geologist as being of some importance. Veins of magnetic ore occur in the gneis of this county; they are, however, of less consequence than the deposits of specular ore. Bog ores are also abundantly distributed throughout the northern counties.

In the western part of the State, there are deposits of iron ore of considerable value in strata of the Clinton group. They form a band of small thickness, but lie near the surface, so as to be easily mined. The ore is a compact and earthy peroxide, often fossiliferous; and there were, in 1849, five furnaces using it.

Art. VI.—THE MINING OF COAL, &c., &c. By A. T. Ponson. No. 6.

[Continued from page 66, Vol. VII.]

Section 7.—Methods of searching for and discovering coal-beds.

95. *Various methods useful in searching for coal beds.*

The object in view in searching for coal is to establish the fact of its existence at any given spot. The point of starting may be on the surface of the earth, or in a mine, in which latter case the purpose is to find a seam momentarily lost. In this latter case, the proceedings are a part of the working of coal mines; strictly speaking, those commencing upon the surface form the subject to which the attention of the reader is at present directed.

The operations of this kind are performed in different ways according to the end in view. When the search should be made *a priori*, that is to say, in a country where there does not exist any trace of improvement, the first efforts consist in geological and mineralogical investigations tending to discover the formations known as capable of being the carboniferous, and the indications, which, making a presentiment of the presence of coal, led to the discovery of its outcrops. But as these observations are not possible to be made, except in the instance in which the seams show themselves at some point of the surface of the ground, and as the indications of the carboniferous formation are not a sufficient motive for the establishment of immediate works of mining, it is necessary, first of all things, to be assured if the traces ob-

served transform themselves in the depth, into workable strata, to know their direction, inclination, and the other circumstances of the deposit. We resort, then, to other modes of exploration as a proper supplement to the preceding, to wit:

1st. Trenches, small horizontal, open excavations, designed to prove the outcrop of the seams at a shallow depth beneath the surface.

2d. Borings, by means of which we examine the interior of the earth and obtain an account of the nature of the substances contained in its bosom.

3d. In short, pits and galleries, vertical excavations, inclined or horizontal ones made in the seam or the enclosing rocks. Their section is such that the miner is able to enter and examine in place all the characters of the strata which it is important to know.

96. *Geological examination of the surface of the ground.*

The first things to be done in searching for coal in a district where no improvements exist, are an exclusive resort to geology and mineralogy. The explorer is guided only by the external characters of the surface and the phenomena he is able to observe.

The degree of elevation which the position of a series holds cannot be a guide, since carboniferous deposits are sometimes imbedded at considerable depths beneath the sea, sometimes deposited in the bosom of hills elevated far above the level of the same. Sometimes they are entirely uncovered, or rather simply masked from sight by a deposit of vegetable soil; oftentimes they are buried beneath plains, valleys and hills, where they are covered by deposits of sand, or by secondary and tertiary strata. The figure and conformation of the ground, which, in other formations, never misleads the eye of the experienced geologist, are a feeble resource here, in consequence of the facility with which the rocks of the coal series are decomposed and broken down under the influence of meteorological action. The only peculiarities of form which can be of any service here, arise from the fact that, in most cases, the combustibles are contained in hills of a gentle slope and of rounded summits.

The explorer knowing the formations in which there is a hope of finding coal to the exclusion of others, should not bestow attention, for example, upon the series of igneous origin, as granite or gneis, &c., nor delay himself with the lower transition, nor with the deposits of a more recent date than the coal formation, if they are of great puissance; but he will carefully examine the beds of fern-bearing limestone, which, being little affected by atmospheric influences, always show themselves in a distinct manner on the surface of the ground. He will seek to discover if they contain any organized remains which are an indication of

the presence of combustible; if such are detected, he takes a formation of this kind for a point of departure, and advances along a line perpendicular to its direction, passing over successively all the strata belonging to the recent series; he examines every point where the rocks are uncovered; he visits the pits, the beds of torrents and rivers, the cliffs of hills, in a word, every natural or artificial excavation; he investigates the blocks of schist or sandstone he meets in his progress; he carefully searches for fragments and even grains of coal accidentally broken from their deposit by the force of rains, and transported a certain distance by natural currents, and he judges of the distance at which the deposit should be found by the degree of sharpness of its edges or corners and rounded form of the fragments.

Knowing that coal is subjected to all the inflections of the enclosing rocks; that a series of beds alternately psalmitico-schistose is at once a near indication, his attention will be given principally to the sandstones, because being less subject to disintegration than the slates, he can readily discern them. If he finds any vegetable impressions, or any nodules (rognons) of carbonate of iron, it is a still more certain indication of the presence of the mineral coal. In short, if he finds interspersed between the beds of the psalmitico-argillaceous mass, and following the general direction of the strata, a simple trace presenting the appearance of soot, a layer of black or rotten slate, a leaflet of thin earth, or any other analogous substance; if, in a word, that selvage contains any parcels of coal, it is probable that he will have found an outcrop.*

When the locality which is the object of examination affords all the characteristics of a coal formation, the geologist has reached the limit of the field of his operations, and the labors of the miner now commence. He investigates to determine if the outcrops discovered are those of workable beds having some degree of continuity; he determines their nature, direction, inclination; in a word, he assures himself whether the future establishment will possess a chance of success.

97. *Searching by means of trenches.*

Trenches are dug only to such a depth as may be necessary to establish if the outcrop discovered is really that of a coal bed, and to obtain some proximate idea of its regularity, bearing, and size. The excavation being opened on the black trace presumed to be an outcrop, it is followed down on the course of the strata. If the coal

* However slight may be the indications thus found, the explorer will not decide without deep explorations, for he knows that the thickness of coal is strikingly diminished near the outcrop; that often beds of many metres in thickness show themselves at the surface of the ground by a simple trace of black slate; and that, in short, the outcrop itself is sometimes entirely suppressed, a circumstance which can be ascribed only to the decomposition of the combustible under the influence of atmospheric agents.

really exists, its earthy aspect is far from promising a satisfactory result. This, however, is far from being a matter of any anxiety to the miner, for he knows that this appearance, which is caused by the clay in the cavities and natural fissures, ceases when the excavation reaches some metres in depth. In short, as he advances, the sombre and bituminous color becomes more and more opaque. He meets fragments which are black, angular, and brilliant, scattered in the mass; next he sees stratified upon the foot wall coal which is solid in appearance, but in reality very friable; in short, the walls become regular and parallel. He then pushes for some metres an excavation perpendicular to the first—that is to say, in the course of its extension; it is now that he measures the thickness of the seam, and determines its direction and inclination, without neglecting to observe all the time the enclosing strata, in order to guard against the derangements which affect the conclusions drawn from the facts obtained.

A seam being thus proved, we seek the outcrop of other parallel strata by pursuing for an indefinite distance the trenching, which can be done perpendicularly to the course known. This excavation pushed to the right or left of the point first explored gives the elements of a body of strata, and makes known the breadth of the basin.

Works of this sort are useful in a level country, where the seams of coal are only masked by the vegetable soil or by some thin beds of clay; they are, however, utterly impracticable if the coal series is covered by strata even of a moderate thickness. The cultivation of the fields is sometimes an obstacle to this manner of proceeding; but, however it may be, the method is simple and cheap, although it affords only insufficient results.

98. *To discover carboniferous formations when masked by deposits more recent than they are.*

If, as any one may perceive, the search for coal is often easy in formations that outcrop, it is far otherwise when very powerful secondary or tertiary strata are superincumbent on the seams; the difficulties in this case increase with the thickness of the deposit. When the covering series consists of sand, gravel, or other alluvial strata, it is rare, however deep the digging, that fragments of coal or the enclosing rocks are encountered; and nevertheless, when in sinking lower their thickness only sensibly diminishes, it is impossible to discover an outcrop at any point on the surface.

The secondary and tertiary series sometimes contain the debris of the formation which they cover, but these indications render only probable the existence of coal in the district which is the object of exploration. If the covering series is not very thick, or if it is broken by valleys and high hills, the rivers or torrents which furrow the surface may have excavated it below

the crest of the carboniferous formation, so that an inspection alone of the rocks will permit their classification; it is thus that outcrops have been exposed. In such case, one can act according to the principles above stated; but similar local depositions are rare, and the indications they can furnish are altogether insufficient and uncertain. Under these circumstances, the only efficient means to obtain a knowledge of the nature of the lower rocks of the covering series, are borings and shafts and galleries.

99. *Borings, as applied to the search for coal seams.*

It would be very hazardous to undertake works for searching in a very powerful and continued series of dead ground; prudence seems to demand of the miner to limit himself to search only the prolongation of the basin by taking the general direction, and excavating the lower strata by means of successive borings at short distances from each other; thus he will proceed from what is known to the unknown, in following step by step the prolongation of the strata already explored. He will be careful to continue in the axis of the basin in order not to risk being led astray into the enclosing formations if the deposit momentarily recedes, and to be able to change the direction of the line of search when the seams inflect by abandoning their primitive direction.

As he examines attentively the nature and the relative age of the rocks traversed, he will perceive at once if the bore penetrates a formation anterior to the coal formation. In this case, it is useless to proceed further: but it is advantageous to take an exact note of the position and the nature of the various strata, in order to compare these results with those to be obtained at other points where more fruitful soundings may be made.

100. *Works of exploration.*

If, after having detected the presence of coal, any one should proceed in order to establish works, he might risk the loss of considerable capital without a result; for the seams may be irregularly stratified, without continuity or with frequent faults; in other words, unworkable. The prudent miner foresees these troublesome results, in determining previously the inclination and extension of the seams, their succession, thickness, and continuity, and the nature of the enclosing rocks, whether it is done by the aid of pits and galleries, or by means of a series of soundings conveniently arranged in relation to each other. The complementary works of searching are called *works of exploration.*

101. *To determine, by boring, the inclination and direction of a coal seam.*

The first notion which an explorer should seek to obtain in the works of exploration relates to the inclination of the seams

of coal, from which the direction and thickness are naturally derived. This element is essential, in order to fix the place of a series of borings designed to form a view of the stratifications and to indicate the principal characteristics of the deposit. It is always possible to determine the inclination by means of three borings, provided they are not arranged in a right line; but as this method is tedious and costly, an attempt has been made to arrive at the same result by means of a single bore. This is the end* achieved recently by M. Evrard, professor of chemistry, at Valenciennes, and Engineer Souch.

The proceeding consists in separating at the bottom of the bore a piece or cylinder of coal, slate or sandstone, breaking it off, and bringing it to the surface. The specimen being placed in a position analogous to that which it primitively occupied, one can detect the elongation of the beds by considering the leaflets of slate as the expression of the inclination of the series. Thus we can operate at the junction of the seams and the enclosing rocks.

The operation is as follows: After having suitably prepared the bottom of the bore, a chisel is let down, designed to trace a line which the specimen may bear when brought to the surface; but as the "*orientation*" of that tool should be known at the moment it works, an artful method is adopted by means of which it is practicable to know its exact position at every moment of its descent. The trepan being placed above the orifice of the bored pit, there is adjusted upon the rod, strictly in the plane of the edge, a slide which is made to descend to the ground; another is then placed near the top of the scaffold and in the plane of the first; the latter is removed to let down a new piece of the rod; the first is adjusted above the second, and thus in succession until the tool reaches the bottom of the bore; the whole is turned entirely in order to bring the chisel into a determinate direction (in the plane, for instance, of the meridian); then making it strike some light blows, a mark is impressed on the bottom. It is easy to obtain the parallelism of the slides by means of a plumb line.

This delicate operation being accomplished, a *cutting-out machine* is used for separating and raising the specimen bearing the imprint of the chisel. The cutting machine of M. Evrard is composed of a toothed crown, surmounted by a hollow muff in which the sample is secured: in working the instrument like an auger, a hollow is cut in the circumference of the bottom; the result of this is a cylinder, which is broken at the base by some sharp, jerking oscillations of the rod. The tool usually brings

* The first inventions having this end in view were made by James Ryan, in Ireland, who obtained a patent for an instrument analogous to that of M. Evrard.—*See Edinburgh Encyclopedia*, vol. 14, pp. 830—*New mode of boring, by J. Ryan.*

up the piece with it, because the dirt lodging between the blades (teeth) and the other interstices forms a kind of mastic proper to unite the two objects. If the cylinder remains at the bottom, it can be brought up by other tools.

M. Kindt has recently invented an apparatus far more convenient for isolating and breaking off the cylindrical mass.

The tool which is employed to bore annularly around the core it is intended to detach, consists of two arms of iron which, starting from the shaft of the tool, terminate at the lower end in a strong ring, to which are fixed the cutters intended to bore the rock. The exterior diameter of the ring should be at least one fourth of an inch smaller than the hole, in order that the cutters may project a little.

This projection is absolutely necessary, because otherwise the ring would soon get fastened in the hole, and the core would be broken off and extracted too soon. This projection facilitates, during the drilling, the disengagement of the water and the mud between the contour of the ring and the sides of the hole. It is also with a view to favor this disengagement, that there are cut small grooves in both the exterior and interior contour of the ring. The cutters, to the number of 6 or 8, according to the diameter of the hole, are fixed to the ring by iron rivets. Experience has shown that it is most advantageous to place the edge of the cutters radially.

The trepan is constructed on the same principle as the preceding, only in place of attaching the ring to two arms, it is riveted to a wrought iron cylinder.

This is found, aside from motives of economy, to be able to extract cores of considerable size in rocks of a feeble consistence.

Another tool is designed to detach and withdraw the cylindrical cores which have been disengaged by the preceding instruments. It is composed of a cylinder of wrought iron, of a diameter appropriate to that of the hole already bored, provided at its lower end with an iron ring fastened by rivets. This ring bears on its inner surface several steel teeth, movable around horizontal axes, and of such a size that their points nearly meet in the centre of the cylinder when open. In the interior of the large cylinder is an iron ring, which can be moved vertically, and is suspended to two arms which meet in one shaft.

To extract a core with the instruments above described, they commence by cleaning the hole as perfectly as possible. Then is introduced one of the two first described tools, fixed at the extremity of the boring rods; arrived at the bottom, light blows are given with a hammer, the rods at the same time receiving a continuous movement of rotation.

This proceeding is maintained until the contact of the top of the core with the arms of the tool arrests it. This is then withdrawn and replaced by the second. This is fastened to the shaft by a tenon; the ring in the interior of the cylinder is suspended by its upper extremity to a cord.

When the apparatus has arrived on the top of the core, the cord attached to the ring is drawn up until the ring is near the top of the cylinder, which descends meanwhile around the core. The teeth, fixed at the lower extremity of the cylinder, are at the same time raised by contact with the top of the core, and assume a nearly upright position.

When the apparatus arrives at the bottom of the hole, the ring is let fall by its own weight, and lodging between the sides of the cylinder and the teeth, it forces their points into the core. By now drawing up the machine the core is broken off and comes up with it. In tender rocks, the core detaches itself easily by the traction necessary to draw up the instrument, but in rocks of a firmer consistence it is necessary first to break it off by shaking the lever attached to the boring rods. In all cases, the greatest care should be taken to withdraw the tool without giving it any movement of rotation, in order that the core, arriving to the light in the same position it occupied in the earth, can show with certainty the direction and inclination of the beds. M. Kindt has succeeded by this means to withdraw from a depth of nearly nine hundred feet cylindrical cores of ten inches in diameter, and more than three feet in length.

This process succeeds best in coal beds, on account of the fragility and feeble specific gravity of this substance, of which the debris spread in the water escapes easily through the grooves in the sides of the borer.

(To be continued.)

ART. VII.—GOLD ORES AND THEIR WORKING. By STEPHEN P. LEEDS.

(Continued from Page 32, Vol. VII.)

THE stamp-heads are frequently cast with a hollow square at the upper end, for the purpose of inserting the stamp shaft. The objections to this plan are, that the timber is liable to become loose by the continued concussion of the stamp-head upon the ore, and to a corresponding extent to become ineffectual and troublesome. A better plan would be, to give to the upper end of the stamp-head the form of the frustrum of a pyramid, and make the stamp shaft hollow to receive it; if securely banded, and tightly adjusted, every blow of the stamp upon the ore will make each stamp-head more firmly connected with its shaft.

The stamp-heads should weigh from sixty to one hundred pounds, or more, each; the weight should be regulated by the character of the ore.

THE ARRASTRE.

The arrastre may be considered as belonging to the crushing as well as the amalgamating department. In fact, it is truly the connecting link between the two branches. The arrastre is sometimes called the Tahona. It consists, like the Chilian Mill, of a stone bed, surrounded by wooden stave-work, forming a large tub of which the stone bed forms the bottom. An upright shaft is "stepped" upon this bed, from which shaft four arms project at right angles with it, extending to within about one inch of the rim, and at an elevation of about two feet from the surface of the bed. To each of these arms is attached a fragment of rock, called the "drag," by means of two short chains; one end of each being secured to an iron hook, firmly fixed in the upper surface of the drag; the other end is fastened by a hooked rod which passes through the arm, having upon its upper end a screw termination, for the purpose of elevating or depressing the position of the front of the drag. The drags are irregular parallelopipedons, the under surface of which is "dressed down" to a smooth face; upon the upper surface four iron hooks are securely placed, two upon each side; they are usually about two and a half feet long, by two feet wide, and one foot thick; their weight is from two hundred and fifty to four hundred pounds. The drags should be run with their front slightly elevated; this position can be attained by means of the screw rods which pass through the arms, and cause the drags to ride upon the sands, and produce a still further reduction of the size of their grains.

Those arrastres with two drags only, are called "Sencillas," those with four, "de Marcas;" these last are the most used. As the intention of the arrastre is not only to reduce the sands, but also to brighten or polish the auriferous particles, by removing by the friction of the drags the ferruginous oxide which frequently encases them, it is evident that the "de Marca" is better adapted to meet those requirements than the "Sencilla." When the face of this drag wears away by use, its position has but to be reversed, to render it efficient; hence the necessity of the four hooked rods.

The diameter of the bed is about six feet. Its thickness from six to eighteen inches. There are four grooves cut into the rock, at right angles with the shaft, extending from about four inches from the shaft to within the same distance of the rim. These grooves are about one inch deep in the centre, and gradually diminish in depth as they approach either end. They are about one inch and a quarter in width; they are filled with quicksilver when the drags are started.

It will be found advantageous to attach pieces of heavy iron chains, of the size called log chain, to each drag, by connecting both ends of the chain to the spare hooks, and letting it drag, loop-like, in the sands; its effect will be to plough up the sands;

care of course being taken to prevent the length of the chain from allowing it to pass under the drags.

The arrastres are driven from seven to ten revolutions per minute; I would advise the former, in preference to the latter number. They should be fed regularly at from one to two bushels per hour. Where a sufficient number of arrastres are worked, to take all the ore at a slower rate, it would be better to feed them at the rate of one bushel, only, per hour, or about three fourths of a ton for each twelve hours. *Regularity* and *slowness* are again enjoined upon the labor here.

Upon the average class of ores, the arrastre should be run from forty-eight to seventy-two hours, before "cleaning up." To facilitate this operation, a small hole should be made at the base of the "tub," on the level of the bed, through which the slime and amalgam could be easily washed into a vessel placed to receive them. This hole should be securely closed while the arrastre is in operation.

The usual method of supplying the water is over the rim on one side, and allowing the discharge to take place over the rim upon the opposite side; but a *central discharge* will be found the best if tried. After the arrastre has been running twenty-four hours, an occasional addition of a small quantity of quicksilver will be attended with favorable results. One or two quarts of wood ashes, freed from charcoal by sifting, added occasionally, will, by keeping a bright surface on the quicksilver, greatly facilitate the amalgamation. The ashes should be freed from charcoal not only because it would be liable to obstruct the discharge vent for the water, but also, because it possesses an attraction for metallic substances, and would be liable to remove much of the fine floating gold.

Properly attended and carefully regulated, I consider the arrastre as the best and most efficient amalgamator at present in use; perhaps a few quotations may be apposite, to evince that others entertain similar views on this point with myself.

"I consider the arrastre as the best means of obtaining the gold from the ore after its decomposition."—*MS. Correspondence.*

"To extract the gold Mr. Boussingault has introduced the Mexican arrastre, for grinding and amalgamating the concentrated ore, in one operation. This has been found also to answer, as the loss of twenty-five per cent., which had been sustained by washing the cabegas in the batea, is by the above method reduced to three per cent."—*R port of Colombian Mining Association,* 1831.

"The arrastres have also been brought to a great degree of perfection, and the loss on amalgamation reduced to merely nothing."—*Bodman's Report.*

"The experiments on the concentration of the stamped ore having been terminated, and the arrastre completed, a trial of the

American system of amalgamation for the final extraction of the gold had been made. * * * * Those experiments seem to prove: 1. That the extraction of the gold from the auriferous pyrites can be easily performed by the amalgamation in the arrastre. 2. That in about thirty-eight hours' labor, ninety-seven per cent. has been extracted of the gold contained in the mineral. * * * These experiments were intended to be continued with some alterations; but as no doubt remained as to the advantages of immediately introducing this method at Marmato, another arrastre was to be erected without delay. It is also recommended to adopt the same process at Pamplona, where in all probability the amalgamation in the arrastre can be executed even with more facility than at Marmato, on account of the better quality of the mineral in that district."—*Boussingault's Letters to Colombian Association.*

To evince the high estimation in which the Mexicans held the arrastre, no better proof could be adduced than the following statement of the number worked upon the mines of one company—the Anglo-Mexican.

In "Escalera" 51, in "Dolores" 30, in "Salgado" 42, in "Pastita" 29, in "Rocha" 42, and in "San Austin" 20; making in all 214.

"The arrastres cost about $1,000 each in Mexco. They are driven at twenty-five revolutions per minute. Each arrastre requires seven mules per day; being three relays of two mules each, and one extra mule, in case of accident. They usually grind from ten to twelve hundred weight per day.

"The quicksilver must be added at different times, and not thrown in all at once. The first stirrings must be performed with softness and gentleness, lest the quicksilver should be too minutely divided, and form "lis," which is the term applied when it divides into almost imperceptible particles."—*Gamba on Amalgamation.*

AMALGAMATION AND WASHING.

The amalgamation and washing are almost inseparably connected; in fact the amalgamation cannot proceed without the washing is in a state of forwardness or blended with it at the same time. As before stated, the arrastre is the connecting link between the crushing and amalgamating operation, and, it might have been added, it also embraces a portion of the washing force. The whole of the working of gold ores by the net process is from the first to the last step, strictly speaking, a washing method; as the sole purpose of the water appears to be to remove the light particles of non-metallic matter. The longer the ores are kept under operation, the greater the percentage of the gold contained in them that will be obtained at the termination of the work. Upon nearly all of the gold mines that I have visited, I find that from the time the ore is crushed until it passes away under the class of "tailings" not over one hour is allowed to elapse; and

very frequently the ore is crushed, amalgamated and washed, in less than one third of that brief time. No wonder that so few gold mines can be made to pay expenses. I question if under such circumstances even one tenth of the gold is saved. From the time the ores are crushed until they are put upon the "tailing" heap, at least two days should pass by, with them under working operation; and even this time is too brief. If with the "rests" and slowly moving action, the ores could be kept one month under constant changes, the results obtained from those mines that are now losing concerns, would be such as would surprise by their value all interested in them. There is no reason why sufficient time should not be allowed them; the appliances are not expensive; in fact the more simple the mechanical appurtenances, the better is the yield; consequently there should be ample force in the form of tanks, arrastres, stirring-bowls, rockers, shaking-tables, riffles, Silliman's bowls, and in short, the whole retinue of common applications so familiar to the worker on auriferous mines. Let the ores be worked and pass into tanks; there let them remain for two days at least; then let them be passed through the next appliance, and into tanks again with an additional "rest": and so on, until with working and "resting," they have been subjected to the trial of the whole host of washing and amalgamating contrivances. After the first batch of the ores begin to yield their treasures, the returns from the remainder can be obtained every one or two days. It is useless to assert that any one amalgamating machine can extract all the gold from the ore in one manipulation; IT IS AN UTTER IMPOSSIBILITY.

THE STIRRING BOWL.

The object of this appliance is obvious. As the slime is discharged from the Chilian Mill, or else from the arrastre, into the stirring bowl, the constant movement of the "fingers" agitates it, and by stirring up the quicksilver which is placed upon the bottom of the bowl, both are brought into frequent and prolonged contact with each other, and the amalgamation consequently proceeds. Being attended with but little cost in their construction, and entailing but a trifling expenditure of motive power, they form a very useful adjunct to the Chilian Mill or to the arrastre. Their form is that of a straight-sided tub, about three feet in diameter and nine inches deep. Those in use at the Rutherford Mines, N. C., are formed with double-plank bottoms and with one-inch plank sides. The plank is bent around the bottom, by sawing at about two inches distant nearly through the plank; and by soaking or steaming it thoroughly before it is nailed to the bottom, it is easily bent to the correct form. This plan will be found tighter and cheaper than if the tub should be made of staves. The supply of water is received direct from the Chilian Mill or the arrastre, bearing the slime with it through the side of the bowl by means of a trough, and the discharge is nearly in the centre, at an eleva-

tion of about two and a half inches from the bottom. The bottom must be perfectly flat and level. A shaft about five inches square is "stepped" in the centre of the bowl, and should be driven by a belt connected with the shaft of the Chilian Mill, or the arrastre, by a small drum upon each shaft; the speed of the revolutions should be about the same as that of the arrastre. The bowl must be immovable. Attached to the shaft is an arm, carrying six fingers, three on each side of the centre, so placed that the three upon one side shall follow the spaces between the three upon the other side. These fingers are about one foot in length, by two and a half inches wide, with two and a half inches space between each. They should run within about one eighth of an inch of the bottom of the bowl. The arm is attached to the shaft by a screw bolt and nut, and to allow for the wear of the fingers, the hole in the shaft is cut about four inches long, by three-fourths of an inch wide. The adjustment of the arm can be accomplished in a moment. Four bowls will be enough to take the slime of one arrastre. The slime should pass from the arrastre into two of the bowls, and from them into the other two. The "cleaning up" should be managed like that of the arrastre.

THE TYROLEAN BOWL.

This bowl is not used singly, but is usually arranged in sets, so that the slime may pass through several bowls before it is entirely discarded, or thrown out upon the heap of "tailings." It is generally used in connection with other amalgamating or washing appliances. It consists of a stationary wooden basin, in which is made to revolve, by means of a shaft, a solid block, with a funnel-shaped cavity. By ribs that are fixed to the bottom of a block, the slimes are brought into immediate contact with the mercury which covers the bottom of the bowl. The slimes are passed through several of these bowls, which are placed, stair-like, one above another; they flow from the upper bowl into the centre of the block, and passing down through it, traverse the quicksilver beneath it, and rise to the level of the discharge spout, from whence they pass into the next bowl below, and thus continue through the whole series. An iron arm through which the shaft passes, crosses from one side of the block to the other, giving the motion to it, and by means of a screw any required elevation of the block from the bottom of the basin can be attained. The bowl is about twelve inches in diameter by six inches deep. The block is about eight inches deep, and the aperture through which the slimes pass is from two and a half to three inches in diameter. This method of washing the auriferous slimes is held in high repute in the Tyrol, wher· the small percentage of gold in the auriferous pyrites requires close amalgamation to obtain it. It is a simple and cheaply constructed machine, and in connection with other contrivances, is worthy a place upon every mine.

THE ROCKER.

The Rocker stands pre-eminent among the appliances for amalgamating and washing the auriferous sands. The operations of nature are usually safe to follow, when we can find them applied to precisely the same degree of action, and producing similar results to those we wish to obtain. I studied at every opportunity the natural action of rivulets in their washing the sands over which they flowed; and found that the process was much more effectual, and at the same time more quickly performed, when there was a slight fall into a shallow basin whose point of discharge was as one to three of the maximum of the fall. When the point of discharge was less than that proportion, the action was too violent and rapid, and the sands were carried away with the too great motion of the water, and the basin kept entirely free from the more heavy kinds of sand. When the point of discharge exceeded that proportion, the sands remained in the basin, and the washing was more or less imperfect, according to the elevation of the discharging point. When that point was so high as to be nearly equal to the ingress of the water, the sands were not removed, but accumulated until the basin became filled. A similar occurrence is too frequently observed in the rocker, when through want of proper attention the sands "pack." If the sands are of a heavy kind, such as the pyritous ore, they will pack in the riffles of the rocker, and then there will be a great liability of a loss of the quicksilver, from its "riding" the sands, and thus being crowded out of the rocker. On the other hand, should the sands be of a lower specific gravity, such as those of silica, the probability would be that the sands would "ride" the quicksilver, and unless the quantity of mercury was nearly enough to fill the riffles, a bed of sand would remain in them, and all the sand which subsequently was carried by the stream into the rocker, would be borne along without coming in contact with the quicksilver. In either case the amalgamation would be suspended, and the auriferous particles would be washed away and lost.

The chief object of the rocker is to bring all, or nearly so, of the particles of slime into immediate contact with the mercury, that it may freely amalgamate the gold contained in it. Some persons, to accomplish this result, arrange the position of their rockers with a slightly inclined surface, to produce a more rapid flow of water, and to increase the force with which the sands are brought into contact with the quicksilver. This plan does not meet the intentions of those who so place them, as it causes the water to bear off many of the lighter particles of gold by its increased velocity, and it will be found that such a position of the rocker does not bring the sands fully into contact with the mercury. The rocker should be placed upon a dead level, the streams should be very diminutive, and the sands *very slowly* fed into it; such an arrangement will produce the most full returns of gold.

The great principle involved in amalgamation is to protract the contact of the gold and mercury as long as possible, without making the work too slow for practical purposes. The quicksilver in such a case acts as a mechanical solvent of the gold; the chemical properties of either are not at all changed by the intermixture; and as a necessary consequence, the solution is the more perfect the longer their contiguity is maintained.

The rocker should have a long, *slow*, rolling motion; swaying about thirty times to the minute. At Gold Hill, Rowan County, N.C., the mill rockers are moved by crank motion, and sway thirty times to the minute, having a motion of about two feet. I was told there that they did not like the crank motion as well as the direct application of manual labor; as the speed of the steam-engine was not always uniform, and as the motion was one which required close attention and some exercise of judgment.

When the velocity was too great the quicksilver was liable to be thrown out of the rocker; to prevent such an occurrence, the simple contrivance of a leather cap was tacked over each extremity of the riffles.

The upper riffles in the rocker should be as full of quicksilver as they will hold. A good rule to observe in this respect is to fill the upper riffle, and to continue to keep it so by repeated additions, until the second and third riffles are also full. There need be no fear about an excess of mercury; the larger the quantity, of course the more extended will be the surface spread out to receive the gold, and the chances of contact are, consequently, correspondingly increased. Nor need any apprehension be entertained as to the loss of mercury by such an arrangement; if the rocker is rightly constructed, and placed upon a perfect level. If under any circumstances the rocker discharges the mercury, the riffles must be altered in their depth or shape, the circle of the rocker must be examined to discover if it is cut true; the level must be applied to its synclinal axis; the application of the motion must be noticed, to determine that it is not accompanied with a jerk, but is uniform and regular; the quantity of the water must be attended to, that it is not allowed to rush in too great a quantity over the rocker; and the amount of sand passing must be kept within the moderate limits which will keep the riffles clear, or nearly so, and prevent the covering, or the crowding out, of the mercury by packing.

The rocker is formed from a log hollowed out like a canoe; the bottom is cut by grooves or "riffles" in a transverse direction, which deepen at their centres, but are shallow at their extremities. They are cut in various shapes, some with an oval depression, some very shallow and broad, others with a flat bottom and sloping sides; this last form is the most efficacious, from the fact that it spreads the quicksilver out in a flat surface, and affords a slightly abrupt fall of the slimes upon it. The upper riffle is usually about

two feet from the head of the rocker, and the others are cut from the same to one half that distance from each other, except the last, which is usually placed within about four inches of the tail of the rocker, to arrest any quicksilver that may by accident have washed thus far down with the "tailings" or washed sands.

From the observations which I made upon the action of water upon the sands in rivulets, I was led to produce a modification in the shape of the rocker, which I have found by experiment to be a decided improvement upon the old form. The principle is to give a series of slight falls to the current of water into the basins or riffles, sufficient to produce a "boil" in the water; and also to expose the greatest possible surface of mercury to the passing sands. This latter is accomplished by making a "wallow," or slight depression between each riffle, and placing mercury within it, as well as in the riffles. The long space between the lowest and next riffle is left a dead level.

I make the wallows between the riffles as shallow as possible, not exceeding at their maximum depth one fourth of an inch. It is better to make these wallows by rubbing down their beds with pummice stone, or sand and stone, than to cut them with a sharp instrument; as by that process the wood obtains a somewhat rough and velvet-like surface, which has a tendency to catch and retain the fine particles of gold.

The experience gained in deposit washing, of the point of deposition of the particles of gold, evinces that the bulk of such deposits do not occur, as would naturally be supposed at first thought, in the hollows and indentations into which the waters are rushed, but more frequently, upon, as it were, the very verge of the fall which the waters make into such depressions. The quiet, still, unruffled, glassy flow of the water, just as it is precipitated over the edge of a rapid descent, appears to be peculiarly adapted to the deposit of the gold, for it is on such situations that the richest washings are the most frequently found. In the gentle rise of the wallow, therefore, as the edge of the riffle is approached, will be discovered an endeavor to profit by the lesson traced by the hand of nature, and to produce a favorable position in which the stream of the rocker may let fall its auriferous burden.

I make the fall of the water over the upper side of each riffle to be one inch and a half, and the point of discharge from the riffle to be half an inch above the bottom, leaving the riffle four inches wide, and extending up the sides of the rocker, with a gradually diminishing depth, until it reaches within about four inches of the upper edge of it. The slope on the upper side of the riffles, I make half of an inch; on the lower side, one sixth of an inch. The rockers should be not less than sixteen feet in length, and made of "poplar," or as it is sometimes called, "whitewood." The diameter of the log from which they are made, should be from thirty to thirty-six inches when dressed. Sheet-iron rockers

of the same dimensions would, I should suppose, be preferable, if care was taken to prevent a too rapid oxidation of the metallic surface. The greatest depth of the rocker should be about thirteen inches.

The quantity of water should be simply sufficient to keep the sands in motion; a small stream about the size of a goose quill, will be found abundantly ample. The rocker should be fed *very slowly*, that the supply of sands may only be such as the stream above mentioned will wash freely out of it. It will be found advisable to use clear water if it can be obtained; the results always proving more favorable from the same character of ore, with clear water, than from water holding in suspension earthy or vegetable impurities.

After each "cleaning up of the rockers, they should be effectually scrubbed out, with a stiff scrubbing-brush and sand, to remove the impurities and vegetable depositions left by the water, which if suffered to accumulate upon the sides and bottom of the rocker will detract from its utility.

THE SILLIMAN BOWL.

The Silliman Bowl is constructed to render available the centrifugal motion applied to substances of different specific gravities. It is formed of a block of hard wood, about twenty inches in diameter, and two and a half inches thick. This is bored through the centre to allow the central discharge of the slimes. From the rim of the centre it is cut away with a slope of one inch in six inches to the outer edge, leaving the thickness of the block at that point about three fourths of an inch. To this circumference a wooden rim of three inches wide is securely and tightly nailed. A cross bar of iron is screwed to the exterior of the bottom of the block, through which the shaft passes, and to which it is firmly secured, and is "stepped" upon a perfectly tight but sloping floor below. From the shaft an arm projects about eight inches in length, at the outer end of which a vertical pin is fixed. Several of these bowls are usually placed upon a line with each other, and the motion is communicated to them by a horizontal rod, having holes through it at such distances as will allow it to pass over the pin and rest upon the arm. To the centre of this rod is attached a horizontal connecting rod, worked by a short crank; this gives to the bowls a lateral motion, the whole extent of which is about four inches. The feeding of the bowls is from over the outer rim. They are driven with great velocity to render the centrifugal force more powerful. They make from one hundred and thirty to one hundred and sixty motions to the minute. The effect of this rapid movement is to throw the particles of gold, from their greater density, to the deeper part of the bowl at the circumference, while the lighter slimes pass off with the water through the aperture at the centre. The shafts are so arranged as to be taken down with

great facility, and being always firmly secured to the bowl, afford an easy method of "cleaning up," by placing the bowl over a box, with the ends of the shaft resting axle-like upon each side of it, and giving the bowl a revolving motion accompanied with a few dashes of water. By this method, a set of twenty-four bowls can be washed out in a few minutes. At the Phenix Mine, in North Carolina, by a simple method, the shafts could be arranged in a moment's time. The block had but to be slipped upon the gudgeon of the shaft, be placed into the space which it exactly fitted, and be secured by a key-pin. The sloping floor discharges the slimes that flow from the bowls into a trough, which conveys them into tanks.

I have now concluded the description of the common machinery used in the gold districts of the Middle and Southern States. Were I to attempt the task of portraying each machine that has been placed upon the different mines of the whole field, I should find it as endless as it would be unprofitable. In many cases the sketches would, from necessity, be broken and unconnected; for a few stray fragments of ferruginous basins, oxidized cog-wheels, and numerous massive globular bodies of metallic iron, are all that are left to show the destiny that must ever attend similar ill-directed efforts, to make machinery act contrary to established principles and facts. Their numbers are countless, and in a few brief years their very existence

"Will be forgotten as is their builder's name"—SHELLEY.

To be Continued.

COMMERCIAL ASPECT OF THE MINING INTEREST.

NEW YORK, Sept. 24, 1856.

The operations in mining stocks are very limited, and confined only to those of undoubted merit. Of course we do not notice sales of worthless gold and copper stocks which are bandied back and forth merely for purposes of speculation. Very few of these will ever again be worth the paper upon which they are printed. The time has gone by in which they can lay claim to any attention from those who are engaged in earnest in mining pursuits.

The stocks now chiefly sold are Pennslyvania Coal, Delaware and Hudson Canal, Ward Coal and Iron Cumberland Coal, and a few others. The amount of sales is fair, and prices well sustained. The market for Lake Superior Copper stocks is chiefly in Boston; and for the sale of these, we refer to the letter of our correspondent there.

Annexed is a very interesting table to those engaged in mining pursuits. It shows the dividends declared by the English Companies during the first six months of this year:—

DIVIDENDS PAID BY BRITISH AND IRISH MINES IN 1856.

The following Dividends were paid in the first six months of the year 1856:—

Number of Shares.	Name of Mine.	Total Dividends paid in six months, ending June 30, 1856. Per share.	Amount.
5120	Alfred Consols, copper	£ 0 16 0	£ 4,096 0 0
4000	Bedford United, copper	0 8 0	1,600 0 0
200	Botallack, copper	15 0 0	3,000 0 0
240	Boscean, tin	6 0 0	1,440 0 0
100	Brightside, lead	6 0 0	600 0 0
100	Brynford Hall, lead	8 0 0	800 0 0
2048	Carnyorth, tin	0 6 0	614 0 0
256	Condurrow, copper and tin	6 0 0	1,536 0 0
128	Cwmystwith, lead	15 0 0	1,920 0 0
1024	Devon Great Consols, copper	27 0 0	27,648 0 0
179	Dolcoath, tin	12 10 0	2,237 0 0
649	Ding Dong, tin	6 10 0	4,868 0 0
5700	Exmouth and Adams, lead	0 9 0	2,565 0 0
1400	Eyan	1 10 0	2,100 0 0
300	East Daren, lead	2 0 0	600 0 0
128	East Pool, tin and copper	7 10 0	960 0 0
494	Fowey Consols, copper	3 0 0	1,482 0 0
2560	Foxdale, lead	1 0 0	7,680 0 0
119	Great Work, tin	15 0 0	1,785 0 0
6000	Kingston Down, copper	0 9 6	2,850 0 0
2000	Holyford, copper	0 5 0	500 0 0
160	Levant, tin and copper	4 0 0	640 0 0
20	Laxey, lead and zinc	50 0 0	1,000 0 0
400	Lisburne, lead	9 10 0	3,800 0 0
1024	Mary Ann, lead	3 10 0	3,584 0 0
5000	Mendip Hills, lead	0 5 0	1,250 0 0
20000	Mining Company of Ireland, copper, lead and coal	0 7 0	7,000 0 0
6400	Nether Hearth, lead	0 1 0	320 0 0
6000	North Basset, copper	2 3 0	12,900 0 0
6400	Par Consols, copper and tin	0 18 0	5,760 0 0
1000	Polberro, tin and copper	2 4 8	2,233 0 0
560	Providence, tin	10 0 0	5,600 0 0
200	Phœnix, copper and tin	20 0 0	4,000 0 0
2500	Rhoswydol, lead	0 3 0	375 0 0
512	Rosewarne United, copper	8 0 0	4,096 0 0
496	South Wheal Frances, copper and tin	28 0 0	13,888 0 0
12000	Sortridge Consols, copper	0 2 6	1,500 0 0
256	South Caradon, copper	24 0 0	6,144 0 0
9000	South Tamar, silver-lead	0 10 0	4,500 0 0
280	Spearne Moor, copper	0 15 0	210 0 0
4096	Trewetha, silver-lead	0 6 0	1,228 0 0
6000	Tincroft, copper and tin	0 10 0	3,000 0 0
9600	Tamar Consols, silver-lead	0 2 6	1,200 0 0
520	Trelawny, lead	1 0 0	520 0 0
400	United Mines, copper	2 0 0	800 0 0
20000	Vale of Tony, lead	0 2 3	2,250 0 0
6000	West Basset, copper	2 0 0	12,000 0 0
400	West Seton, copper	18 0 0	7,200 0 0
1024	West Providence, tin	1 10 0	1,536 0 0
512	Wheal Basset, copper	35 0 0	17,920 0 0
256	Wheal Buller, copper	60 0 0	15,360 0 0
250	Wheal Clifford, copper	3 0 0	750 0 0
5000	Wheal Fortescue, copper	0 1 6	375 0 0
1024	Wheal Kitty (Leland), tin	1 0 0	1,024 0 0
448	Wheal Margaret, tin	4 15 0	2,128 0 0
80	Wheal Owles, tin	9 0 0	720 0 0
198	Wheal Seton, tin and copper	9 0 0	1,782 0 0
4096	Wheal Wrey, silver lead	0 14 0	2,868 0 0
	Total		£231,842 0 0

BOSTON, Sept. 24, 1856.

The mining interests of Lake Superior promise a more abundant harvest, speaking generally, than for any previous season, although the product of last year was largely in excess of 1854. It is too early yet, perhaps, to make a

reliable estimate of the result, but we should think the total would reach very nearly 5,500 tons of rough copper.

It is true that a number of mines have failed of success after having cost their shareholders large sums of money; and this has, of course, proved a serious drawback to the development of others; but on the whole, there is much to give encouragement for the future, and we have full confidence that the resources of the Lake Superior Copper region will yet be developed so as to prove the vast richness of that country and the immense value of its mineral property. We propose to give a short review of such mining stocks as are, or have been, known to this market within a period of some years.

Minnesota stands first as a successful mining enterprise, and still bids fair to maintain its high position. No better proof of this is needed than the fact of the stock being in better demand now at $93 to $94 per share, than it was little over a year since, at $30. We have been somewhat curious to ascertain the actual profit at which an original shareholder now stands, and have prepared the following statement, which is believed to be accurate.

We assume three shares as a basis, in order to avoid fractions in the calculation, as an original share would give 6⅔ shares of the present stock, the total having been increased from 3,000 to 20,000 shares.

3 shares old stock now give 20 shares @ $94,	$1,880	
Dividends have been paid equal to $19 on 20 shares,	380	$2,260
Less assessment on 3 old shares @ $22,		66
Net value of 3 old shares,		2,194

In addition to the above, every three shares of the old stock was entitled, *as a dividend*, to *twenty* shares in each of the Rockland Co's Flint Steel River, and Superior (formerly Location B.) Co's, as also three shares in the Lake Superior Co., which would give—

20 shares *Rockland* @ $30,	$600	
Less $2 per share assessed,	40	$560
20 *Flint Steel River* @ $5,	$100	
Less $2.50 per share assessed,	50	50
20 *Superior* @ 7¾,		155
($1 per share the 1st assessment on Superior will be due Oct. 10)		
3 *Lake Superior* (no assessment) @ $20,	60	825
(The first three of the above have 20,000 shares and the latter only 3,000 shares)		
Total for three shares,		$3,019
Profit on *one* original share,		1,006

No allowance has been made for interest on the amounts paid in, but the first cost was so small that the item of interest would amount to a very trifling sum indeed. We think the success of this Company, as forming a species of profitable investment, is beyond that of any other kind of property, and even more so than any other Copper Mining concern in the world, with perhaps one or two exceptions of English Mines.

Pittsburg and Boston, sometimes called "Cliff Mine," has also been very successful, this and the Minnesota being the only ones which have yet paid dividends. The original cost of this stock was $18.50 per share (6,000), now selling at $225, and the dividends since 1849 have been liberal, as will be seen by the following tabular statement, showing a total of $120 per share for eight years:—

	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.
Feb.	——	$7	5	5	7½	10	5	10
Aug.	$10*	7	5	5	7½	8	8	20

* The first dividend was paid in May, 1849, all since February and August.

The above averages $15 each year, but the last three average over $20, and the prospect is now considered good for $30, at least, each year hereafter. It is hardly necessary to say that both this mine and the Minnesota are doing better than ever before, and that the present year's product will not vary much from 1,800 tons of mineral, being an increase of 25 per cent. on last year's amount.

National would sell at $28 to $30 per share, and is considered a very promising mine. It has the famous vein of the Minnesota, and there is every prospect that it will become a dividend paying concern within reasonable time. The recent decision giving to it the territory in dispute with the Minnesota, will add much to the value of the mine. The matter is yet to be heard, however, on an appeal, but there seems little doubt that the National will finally obtain it. The amount paid in is $11 per share in 10,000 shares.

North American is looking better than at former periods, and its managers feel a strong confidence that it is fast approaching a dividend point. The stock is quoted at 30 to 35, but sales are very seldom made in this market, the stock being principally held, we believe, at Pittsburg, Pa.

Rockland is popular among buyers of mining stocks, from the belief with many that it will eventually become a second Minnesota. This feeling, and the fact that the mine is now raising 30 tons of copper per month, has caused the stock to improve to $30, although only $2 per share has ever been paid in. It is not anticipated, however, that any farther assessments will be needed.

Isle Royale has been very popular in this market; and at one time, the stock run up to $19 per share, on the strength of a statement that the product of the year would be 300 tons, and that a dividend of probably $2 per share would be made in January next. The product has not been up to the views of its managers, and will not probably exceed 275 tons. The shares have fallen to $12, and are without activity. The general appearance of the mine, however, is improving, and especially the *third level*, where it was supposed there might be a decline in the richness of the vein. We cannot but have confidence that the mine will prove a valuable property, and the present finances of the Company are highly favorable, being free from debt, with a surplus on hand, and making a profit on each month's business.

Pewabic is a promising "young mine," and is doing remarkably well, the prospect being that the shipments this year will reach 90 tons. The shares sell at 4½ for 1¾ paid in.

Central is also making a very handsome show, and will produce 80 to 100 tons copper this season. As yet there has been only 85 cents per share assessed, and the stock sells at $5. Mining was commenced on a small scale in November, 1854. The product from July 1855, to July, 1856, was 84½ tons, and the mine is steadily increasing in richness. *Quinsy* adjoins the Pewabic, and is doing well, the prospect being good that it will make a valuable mine. The stock is divided into 8,000 shares, on which $7 has been paid in, and it now sells for about $9. *Superior* has the "Minnesota vein," and this gives it a market price beyond its present value from development, as we believe little or no work has ever been done, the name, until very recently, having been "Location B." The proprietors have recently purchased from the *Lake Superior Company*

a valuable tract giving an extension of their vein; and to pay for this ($20,000) an assessment of $1 per share has been levied, and will be due Oct. 10. We presume farther calls must be made hereafter for raising funds to work the mine. *Flint Steel River* sells at $5; and some six or eight months since, it was worth over 50 cents per share. About that time some sudden improvement was made which started the stock up, but, we believe, the prospects then were not fully sustained. This is one of the "off-shoots" of the Minnesota, and some time, perhaps, it will "hit" upon a valuable vein.

Copper Falls, once a popular and apparently promising Company, has completely disappointed its projectors, and, although it may yet prove a paying concern, has been, as it stands at present, a most disastrous adventure for the shareholders. The stock once sold at $65 (June, 1854), since which $12 per share has been assessed, as the stock then stood with 10,000 shares, when the shares were doubled, and $3 more has been paid upon the 20,000 shares, which now sell at $3 each. The introduction of "Ball's" machinery for stamping out copper, it is thought will be a valuable feature for the Company, and there is yet hope that it will become a reasonably good property. The great difficulty with the mine, however, is the lack of barrel and mass copper, the "backbones" which give success to mining enterprises. *Toltec* has also failed to meet the expectations of friends, and has even fallen below what its enemies predicted. There has been assessed $14 per share, and the market value is now $1. Whether the mine will ever prove profitable is a matter which the future working only can determine. The failure of these two mines has proved a serious drawback upon the success of others, as people take what *has been* as their guide for the future. We think, however, that the present policy of mining managers is such as to make a mine *pay* where heretofore the same enterprise would have cleared the pockets of its shareholders, and then called for "more." Our already extended remarks will present an analysis of past mining management, but in another article, we hope to resume the subject.

In addition to the above described mines, there are quite a number of other Companies, the stocks of which have been more or less active here in past times, and to these we can only briefly allude.

Nebraska would now sell at about $2, Huron $2, Norwich $3½, Phœnix $2½, Star $2, Algomak, Winthrop and Dana, 25 cents per share. For Bay State, Bohemian, Fulton, Glen, Native, N. Western, Ripley, Shawmut and Webster, there is no market value. *Forest* has also completely faded out, although at one time selling at $25 per share, since which nearly as much has been assessed and paid in, while the stock is now entirely worthless.

COALS AND COLLIERIES.

ANTHRACITE COAL TRADE.

Shipments by Reading R. R. to Sept. 12,	1,540,651 15	tons.
" Schuylkill Canal,	744,188 13	"
	2,284,885 08	"
Same time last year,	2,440,879 18	"
Decrease in 1856,	156,044 10	"

Delaware and Hudson Co.'s Coal Trade.

To Sept. 6th,	819,208	tons.
To same time last year,	891,888	"
Decrease so far,	72,680	"

Pennsylvania Coal Co.'s Coal Trade.

To Sept. 6th,	869,863	tons.
To same time last year,	845,444	"
Increase so far,	24,419	"

LEHIGH COAL TRADE FOR 1856, BY CANAL.

To September 6th,		
Summit Mines,	198,214 16	tons.
Room Run Mines,	48,625 05	"
East Lehigh Mines,	20,705 19	"
A. Lathrop's Pea Coal,	1,197 07	"
Spring Mountain Mines,	65,687 12	"
East Sugar Loaf Mines,	47,888 09	"
Colerain,	47,386 12	"
Stafford,	9,072 01	"
N. Y. Lehigh Coal Co.,	25,608 12	"
German Pennsylvania Coal Co.,	16,067 11	"
South Spring Mountain Ridge,	18,519 19	"
Hazleton Coal Co.,	86,998 16	"
Cranberry Mines,	48,217 08	"
Diamond Mines,	28,986 10	"
Council Ridge,	81,266 10	"
Buck Mountain Co.,	66,504 19	"
Wilkesbarre Coal Co.,	15,982 07	"
Wyoming Coal,	7,441 19	"
Hartford Coal Co.,	5,688 10	"
Total,	779,901 14	"

Lehigh Valley Railroad.

To Sept. 6th.		
Wm. Milnes & Co.,	58,985 05	tons.
Ratcliff & Johnson's,	2,860 12	"
Packer, Carter & Co.,	22,812 10	"
N. Y. & Lehigh,	7,582 07	"
Sharpe, Leisenring & Co.,	4,414 01	"
German Penna. Coal Co.,	3,525 08	"
Dobbin & Dehaven,	287 00	
Total,	99,462 04	"
By Canal,	779,901 14	"
Total,	879,363 18	"
Same time last year, (Canal)	859,166 00	"
Increase in 1856, so far,	20,197 18	"
The decrease by Canal is	79,264 06	"

CUMBERLAND COAL TRADE FOR 1856.

Shipments to Sept. 18th.

Cumberland Coal and Iron Co.	144,088.14
Percy & Co.	8,175.05
Ætna Coal Co.	7,993.07
Frostburg Coal Co.	120,099.00
Borden Mining Co.	
Allegany Mining Co.	
Carbon Hill Coal Co.	
Wellersburg Coal Co.	

(From the Western port region up to Sept. 6th.)

George's Creek Coal Co.	67,069.10
Swanton Coal Co.	29,807.18
American Coal Co.	40,869.15
Franklin Coal Co.	21,057.11
Lonaconing Coal Co.	18,984.17
Preston Coal Co.	899.05
Hampshire Coal Co.	22,126.04
Total,	480,621.11

NOVA SCOTIA COAL.

The *Cape Breton News* says that the quantity of coal shipped at the Sydney mines to the 1st of August, 1856, was 28,368 chaldrons: shipped to the 1st of August, 1855, 25,500 chaldrons; showing an increase over last year of 3,278 chaldrons.

FREIGHT ON CUMBERLAND COAL.

We present an interesting sketch of the proceedings of the Baltimore and Ohio Railroad Company at a meeting of the stockholders, at which it was determined to advance the freight on Cumberland Coal fifty cents per ton:—

The regular monthly meeting of the Board of Directors of the Baltimore and Ohio Railroad Company, was held at the office of the Company in Baltimore.

The official report of the business of the road for the month of August was presented, and shows the receipts to have been as follows:

	Main Stem.	Washington Branch.	Total for both roads.
For Passengers	$67,844 18	$30,181 80	$98,025 98
For Freight	330,441 70	9,446 12	339,907 82
	$398,285 88	$39,647 92	437,933 80

These figures, compared with the returns for August of last year, exhibit the large increase for the past month of $86,109 60. On freight on the main stem the increase is $72,912 21, and on passengers $9,723 92; on freight on the Washington branch the increase is $460 60, and $3,012 87 on passengers.

The aggregate receipts of the last eleven months, on the whole road, show a total of $1,399,339, 49, which is an increase of $663,992 18 over the receipts of the corresponding period of the previous year. It will be seen that with the earnings of the present month of September (which are expected to approach $500,000), added to the above total of $4,399,339 49, the gross revenue of the fiscal year, ending October 1st, will be within $100,000 or so of the round sum of $5,000,000.

The board had a lengthy session, and had under discussion one or two matters of considerable public interest—the principal being the proposition to advance the freight on coal 50 cents per ton, and at the same time add an increase of power for the accommodation of the trade. Both sides were duly heard on the subject, and in the debate the reasons and arguments for and against the measure were elaborated with considerable earnestness. The

advance was finally carried by a vote of fifteen to fourteen,— and the idea is held out that in consequence the coal trade will now be better accommodated by the railroad company than it has ever been, and the coal dealers of the Cumberland region be thus enabled to meet that pressing demand for the article which is known to exist to an extent which, heretofore, they were unable to do on account of the Baltimore and Ohio railroad not, under the circumstances, supplying in full the necessary cars and motive power.

The subject came up on a report from the committee on transportation and machinery, to whom the matter had been referred at a previous meeting, and of which John H. T. Jerome, Esq., a city director, is chairman. The report sets out with a statement of the cause of delay in acting on the subject,— which was in consequence of the committee having been instructed to confer with the city council on the subject; but having informed that body of their readiness to do so on the first day of the session, they have yet received no answer.

In order to report fully on these subjects, the committee presents the subjoined statements:—

The Baltimore and Ohio Railroad Company has always appreciated the value and importance, present and prospective, of the Coal trade, and for a long series of years has struggled, at periods making great sacrifices, to introduce into consumption, to develope, and to maintain the traffic, in this, the most important of the resources of Western Maryland.

Notwithstanding, parties claiming to represent the great corporations, which own, and work the mines of the Cumberland region, under influences principally beyond the limits of our State, have publicly and privately resorted to the most extraordinary means to arouse prejudice, and to create a want of confidence in the management of this company, by gross misrepresentations of facts, by the most unfair and insidious statements regarding the policy of the company, and by equally unjust insinuations against a portion of its directors; yet the company, on the broad principles by which it is governed, in all legislation, affecting the interests of the State of Maryland and the city of Baltimore, proposes to continue to pursue a liberal policy to the coal trade.

In the infancy of the business a low tariff on coal was urged upon this company, on the ground that when introduced, and its great merit as a fuel, for many purposes, was understood and appreciated, it could readily afford a fully remunerative rate of freight. Yet we find at the commencement of the coal trade in 1844, the rate per ton to Baltimore was $3 66, which continued (with the exception of a special contract of 1 2-3 cents per ton per mile) until 1846.

"Again the company conceded; and in 1846-'47 and '48 the charge was reduced at rates varying from $2 64 to $2 60. per ton.

In 1849, the company again yielded to the pressure and solicitations of the coal representatives, always with their encouraging promises for the future, and further reduced the rate to $2 46, and still again, under their importunities in 1851 and '52, to $1 75 per ton to Locust Point. In 1853 the expense of working railroads having been greatly augmented from causes to which it is unnecessary here to advert, much alarm existed among parties interested in the success of the prosperity of the road. The apprehension became general, that on this large item of its business, which caused immense wear and tear to its road and machinery, the company were suffering an absolute loss. Urgent appeals were made for investigation. Finally, the late lamented John H. Done, Esq., then master of transportation, was called upon for and furnished an "estimate of the cost of hauling coal from Cumberland to Baltimore," which is now on file in the transportation department, which exhibited the actual cost of 1.156 cent. per ton per mile, without interest on any portion of the capital of the road; and, to use his language, "making no allowance for increased cost of repairs of road."

Even with these important omissions, the cost proved to be $2.07 per ton,

the pay being but $1.75, yet much clamor prevailed to oppose any advance.

Great injury to the city of Baltimore and State of Maryland, and destruction to the coal trade and the coal interests were loudly proclaimed and predicted, then as now, if any advance were made. The Board, however, on 1st December, 1858, did advance the rate 50 cents per ton, viz: to $2 25, at which it has remained since that period.

No damage to those great interests resulted from the advance, and they who were confident at that period that the bituminous coal of Maryland was known and appreciated, and would be freely purchased at the advance, proved correct in their predictions.

It is now more widely known and more highly valued, and many believe that it would bear double the advance the committee proposes, and so great is the demand for it, that the capacity of the road would then still be more than taxed to supply consumers. Thus the Company has fostered and built up this trade. It purchased machinery at a high cost, especially for this traffic; submitted to enormous rates of interest for money for its payment, and a further burden was borne, as by such absorption of capital in advance of earnings, dividends were postponed for a long period.

Year after year it reduced its tariff to meet the urgency of the coal interests, to strengthen and to develope the trade, and now, it believes the period has arived when a comprehensive view of the whole interests involved demands an advance.

The board has repeatedly refused to increase its motive power for this trade, unless it be made at least partially remunerative: and the committee, in the rate recommended, propose still to continue to discriminate largely in its favor, and at the same time to recommend an increase of power, by which the company's capacity for the trade will be largely increased.

Attention is requested to the statement of Mr. W. S. Woodside, master of transportation, herewith submitted, marked A, which shows the cost to the company, giving the items in detail, to be $2.19 7-10 per ton, making the calculation for 2,000 lbs. instead of 2,240 lbs. actually transported as a ton, and omitting totally any interest on capital in road. Also to the statement of Mr Henry Tyson, master of machinery, annexed hereto, marked B, which shows

Cost of transporting one ton, one mile, to be	1.63 cent.
Cost of transporting one ton of 2,000 lbs. from Cumberland to Baltimore.	$3 02
Cost of transporting one ton of 2,240 lbs. from Cumberland to Baltimore	3 38

These calculations being based on the actual working expenses and interest at six per cent. on total cost.

He presents a further calculation, in which the interest on the mortgage debt and preferred stock alone is embraced, with the actual working expenses, which shows

The cost per ton per mile	1.35 cent
Cost of transporting one ton of 2,000 lbs. from Cumberland to Baltimore	$2 43
" " " 2,240 " " "	2 72

These rates, by this statement, are thus required, without the payment of one dollar of profit, or dividend, on the stock of the Company held by individuals, the cities of Baltimore and Wheeling, and that unpreferred by the State of Maryland.

In illustration of the accuracy of these estimates, attention is solicited to the fact that no road, so far as the committee can learn, even of level character, in this country or Europe, is worked at or near the present remarkably low charge by this road. One and a half cent per ton per mile, has, on all roads, been regarded as an extreme minimum rate, for summer transportation, whilst the rate which most generally obtains is two cents per ton per mile.

The Reading road, with double track and abundant sidings, and with the most enlarged and economical facilities for the coal trade, with a descending

grade, almost from the mines to Richmond, charges at present, $1 85 per ton for ninety-three miles, and has advertised to advance the rate to $2 on September 1st, its charges being thus upwards of 2 1-8 cents per ton per mile.

The Baltimore and Ohio Railroad Company, with its difficult grades and curvatures, present an anomaly at present, in working at so materially less a charge than roads the most remarkable for easy grades and slight curves.

Much effort has been exhibited to rouse in this city a feeling of antagonism and jealousy in regard to the Chesapeake and Ohio Canal and the trade of the District cities. The committee believes that the large interest of the State of Maryland in the canal should not be made a subject of ruinous rivalry, and that the development of the coal trade will continue at the proposed advance to tax the capacity of both the canal and our own great work.

Influenced by these and numerous other considerations, of which the limit of this report forbids the presentation, the committee recommends the adoption of the following resolution, viz:

Resolved, That an increase of freight on coal of 50 cents per ton from all points of shipment, be charged on and after the 1st October next, and that a drawback of 25 cents per ton be allowed at and from that date on all coal delivered in the city of Baltimore, for the consumption of its inhabitants.

A correspondent of the Baltimore Sun, remarking upon this advance of freight, presents some striking facts relative to the transportation of coal.

The propriety of change of opinion in such institutions (which, unhappily for their stockholders, too frequently indulge in variations of the kind) can sometimes be tested by the unintentional and therefore impartial statements made without any reference to the point in question. In the present matter there is such unintentional witness shown in the following table, which is quite instructive:

Baltimore and Ohio Railroad Work and Profits for a Series of Years.

Year.	Coal.	Merchandise.	Passengers.	Net revenue.
1847	50,000 tons	167,000 tons	187,000	$511,000
1848	67,000 tons	149,000 tons	161,000	552,000
1849	72,000 tons	160,000 tons	165,000	597,000
1850	188,000 tons	160,000 tons	181,000	784,000
1851	189,000 tons	172,000 tons	164,000	658,000
1852	182,000 tons	19[illegible],000 tons	185,000	615,000
1853	225,000 tons	232,000 tons	211,000	798,000
1854	465,000 tons	224,000 tons	251,000	1,619,000
1855	472,000 tons	277,000 tons	292,000	1,6[illegible]1,000

From a table like this, its aggregate and items, could be derived, were there occasion for it, a sufficient number of *equations of condition* to determine with the highest probability (or what is ordinarily termed *certainty*) the share which each branch of traffic and travel contributed to the net revenue. For the present aim, however, it will be enough to indicate a use which every reader can make of it for himself. Thus, in 1849 and 1850, the merchandise was constant, while the coal for the last year increased; and the net revenue is seen to have increased also. Again, as between 1850 and 1852, the coal was sensibly constant, while the merchandise increased, and the net revenue fell off. In 1854 the merchandise decreased, and yet the net revenue more than doubled itself, thus corresponding to the increase in coal. So that it may be stated in general, as the experience of the last nine years, that *the coal traffic and the net revenue have marched together*, while a similar relation cannot be predicated of the merchandise traffic. Indications like these should be full of meaning and emphasis to the managers of an institution from whose business they are derived; and such involuntary testimony should be all the more esteemed, since it has been dictated by neither prejudice nor self-interest.

But this is not all the evidence of the same sort. For instance, the mer-

chandise traffic is hardly half so much as the coal; while the machinery, rolling stock and attendance for it is more than twice as much as for the coal. It should then be charged about four times as much, or (say) nearly $10 per ton, in order to square the account. But in point of fact it is charged less than $7 per ton. So that in reality the coal is overcharged already.

It may be said, however, that a part of the rolling stock (viz. some of the 765 gondolas out of the 2,296 cars attributed to merchandise traffic) has been used in and about the transportation of coal; to eke out the capacity of the 1,024 cars belonging specially to that traffic. This has been so probably, but to a much more inconsiderable extent than the objection would imply. Gondolas have been used only for the transportation of 68,000 tons of coal for company use (which did not pay freight and has entered into none of the preceding calculations), and for a part of the 70,000 tons delivered in the city. If they had even been used for the whole of the city delivery, the calculation of the last paragraph would be affected but about 15 per cent.; still leaving a large margin in favor of the coal, and not affecting the principle at all.

But conceding even that the gondolas were used in the coal trade proper indiscriminately, and thus the phase of 8 made untenable, there are still other unexceptionable data in reserve. Thus, for example, comparing the engine-run for the two branches of traffic, it appears that for every ton of merchandise the locomotive and train ran 5 1-6 miles; for each ton of coal only 2¼ miles, that is to say, for one mile of engine run with coal, there were 2 1-5 miles run with merchandise. Of course, the expense of *haulage* merely, if the miles run with coal and with merchandise were over the same grade throughout (as they are not; for merchandise passes over a heavy grade of 116 feet per mile, which coal does not), would be in the same ratio; and the expense still further of wear and tear of track, cars, &c., will be in the proportion of the whole number of miles run with each traffic, respectively, i. e., coal being 1, merchandise will be 1 81. Combining these two items (which still do not comprehend all the expenses, the remainder of which bear the most heavily upon merchandise), we obtain a proportionate expense per ton for merchandise of $2,90 for every $1 accruing on coal. But for every $1 of revenue that coal yields, merchandise yields but 2.62. There can be no doubt, therefore, in any accounts as between these two branches of traffic, which is profit and which is loss.

FOSSILS, AND THE FORMATION OF CANNEL COAL.

Prof. Newberry exhibited to the Section of the American Association, a series of fossil fishes of great beauty and perfection of preservation, which he said were derived from the carboniterous strata of Ohio—from a locality which he had discovered nearly two years since—and which would rival in the variety and beauty of its fossils the famous fish beds of Solenhofen or Monte Bolca. These fishes were, however, truly carboniferous, occurring near the centre of the Ohio portion of the Allegheny Coal field, both geographically and stratigraphically. It was, therefore, to be compared with the deposit of fossil fishes at Burdee House in Scotland, so fully illustrated by Dr. Hibbert—that in the Ohio deposit were represented with every genus found in the limestones of Burdee House, with a single exception, while in addition there were several genera not yet found in Scotland. The number of species was greater in the American than the Scotch deposits, and all were different. Nearly all the species had, however, a character common to those of Burdee House, in the elaborate ornamentation of their scales and plates, in which they differed from most of the fossil fishes of the coal series. He said the similarity of all and the identity of many of the fossil plants from the coal strata of Europe and America had been noticed, and now the general similarity of the fossil fishes still further indicated the synchronism of the coal period on the two continents. Dr. Newberry said these fish remains were found in a thin stratum of cannel coal lying at the base of a thick bed of bituminous coal; that there

was every reason to conclude that these fishes had inhabited a lagoon or space of open water in the coal-producing marsh, as within a mile or two in any direction the cannel coal and the fish remains ceased to be found; that in this lagoon the smaller fishes lived in great numbers, and, as their teeth proved, lived on vegetables; on these, which were of the genera *Palæoniscus*, *Amblypterus*, *Mekolepis*, etc., the *Cælacantha*, which were carnivorous, subsisted; these in turn becoming the prey of the great sauroid *Megalichthys* and of the sharks. These facts he inferred from the great abundance of the coprolites of the larger fishes, composed almost entirely of the scales and bones of the smaller species which had served them for food. Probably, this lagoon communicated with the open ocean, where the sharks and rays, &c. lived—that it was evidently favorite feeding ground with them—that by some means the entrance was stopped—the lagoon dried up, partially at least—and the dying in great numbers about the same time furnished us with so many beautiful, unmutilated specimens of old and young—that subsequently the surface was occupied by a growth of marsh vegetation, and the bituminous coal was formed without a trace of fishes.

This communication was followed by another paper, belonging to the foregoing, on the mode of formation of cannel coals. These coals, as a class, compared with ordinary bituminous coals, are characterized by greater homogeneity of physical structure and chemical composition, having a more laminated and slaty fracture—impure specimens, conchoidol across the plane of stratification—contain more earthy and more volatile matter (and of course less fixed carbon), and the gases which they evolve have a higher illuminating power. The fossils which they contain are either aquatic or exhibit marks of the action of water. The origin of these differences between cannel and common bituminous coals has been the subject of considerable diversity of opinion among geologists, the peculiar characteristics of cannel having been ascribed to a peculiar and highly resinous vegetation to applied or generated heat, all of which theories, being more or less unsatisfactory, this became one of the problems to which his attention has been specially directed in his investigations of the Geological phenomena of the Ohio system of the Alleghany coal field. His observations upon the cannel coal beds of Ohio, the changes they exhibit in going from one front of outcrop to another, their physical and chemical characters, &c., have resulted in giving him the conviction that the peculiar characters presented by beds of cannel coal are due *to their deposition in water and the commingling with macerated and dissolved vegetable tissue, which for the most part compose them*, and a *considerable portion of animal matter*. 1st. Cannel coal always exhibits a tendency to assume the foliated structure of slates and shells—a structure which it must have derived from aqueous deposition. It often is found shading into bituminous shale—into which it is converted simply by accessions of earthy matter. Bituminous shale and cannel coal may therefore be considered the same substance in different degrees of purity—that is, consolidated ligneous mud, deposited from aqueous suspension with different admixtures of carbonaceous matter; this carbonaceous matter in bituminous shales as in cannel coal, exhibiting a preponderance of volatile matter over fixed carbon, and the gas furnished by it contains a larger proportion of the more volatile hydrocarbon, and possesses a higher illuminating power than that derived from ordinary bituminous coal. The chemical composition of cannel coal, so rich in volatile ingredients, is such as would naturally follow the decomposition of vegetable matter while constantly submerged. What we call the decay of plants after the loss of their vegetable life, is in fact a *combustion*—an oxidation of their hydrogen to form water of their carbon to form carbonic acid. Under water these changes go on still more slowly, and a large portion of the vegetable tissue becomes bituminized. In such circumstances bituminization is the oxidation of the carbon and escape of carbonic acid—with the combination and removal of a portion of the alkaline phosphates and carbonates, &c., which go to form the loss—the union of hydrogen

with the carbon to form carburetted hydrogen and other hydro-carbons—a portion of which are given off and part combine mechanically or chemically with the oxygen, a portion of the alkalies and the earthy matter—to form an almost indestructible mass, destined to serve man for the generation of heat, and which we call coal. It is evident that the more ready the access of oxygen to the carbonaceous matter during the process of bituminization, the larger the proportion of the products of the process will be those of combustion; and the more perfectly the oxygen is excluded, the larger proportion of the more volatile and combustible constituents of the wood will be retained. Of the conservative influence of water and vegetable matter we have ample evidence, not only in the almost incalculable durability of wood when constantly submerged, but in coal itself. In all beds of coal except those where the process of volatilization is complete, in plumbago, and perfectly gasless anthracites, the work of decomposition is constantly going on, and water is to this, as to ordinary combustion, an extinguisher. In this country coal is commonly mined from the outcrop, in some hillside, where it is not covered by standing water; in such circumstances a progressive change is noticeable both in the chemical and physical proportion of the coal from the surface to the point where atmospheric influence ceased. Near the surface it is friable and lustreless, and becomes harder and more brilliant as it is penetrated. Near the surface, too, it is nearly destitute of gases, the proportion of volatile matter increasing as the coal improves in appearance. Of this, Mr. N. was assured by personal examinations of specimens from the outcrop and from deep in the mine. On the contrary, where the outcrop was covered by water, the coal will be found hard and light, and containing nearly its normal quantity of volatile ingredients. The higher illuminating power of the gases of cannel would naturally follow from the preservation of the volatile elements of wood by its continual submersion in a hydrogenous liquid and the presence of a portion of animal matter. That a resinous vegetation could have given its inflammable character to cannel he thought improbable. He had found unchanged resin in bituminous coal, but never in cannel. The greater relative proportion of earthy matter in cannels would be an almost necessary result of covering the vegetable matter with a fluid heavier than air, and of greater power of transporting sediment. The appearance of the fossils previously noticed also seems to prove the aqueous nature of the origin of cannel. Pieces of cannel from England correspond with those in which these fossils are found. Shells, too, are not unfrequently found in the middle of a stratum of cannel. Among the vegetable remains found in this coal by Mr. Newberry are *Stigmariæ*, roots and rootlets of trees which grow in coal-producing marshes, roots so characteristic of the under class of the coal seams, and others. Strata of ordinary bituminous coal usually consist of layers of greater or less thickness of brilliant bitumen, having a conchoidal fracture, alternating thin layers of what is generally cannel, sometimes containing so much earthy matter as to become bituminous shale; at times these layers of cannel are of considerable thickness, and form an important part of the stratum. This arrangement is attributed to the variable quantity of water covering the coal marshes—the cannel-like layers being deposited during the prevalence of higher water, when the fishy remains could naturally have become a portion of the stratum.

ANALYSIS OF ILLINOIS COALS—LA SALLE COAL FIELD.

Quite an extensive analysis of Illinois coals has been made by Prof. Norwood, the State Geologist, which is valuable to all who may feel an interest in our coal fields. These particulars are furnished to us by Mr. H. O. Freeman, the Manager of the La Salle Coal Mining Company, of Illinois.

OFFICE OF LA SALLE COAL MINING CO., LA SALLE, ILL., June 12th, 1856.

DR. J. G. NORWOOD, *State Geologist of Illinois:*

DEAR SIR:—Our Company desire to receive from you in your official capacity as Geologist of Illinois, a statement of your opinion on several points in regard to this coal basin; if not inconsistent with the duties of your office:

1st. As to the quality of the coals found in the three workable beds of this basin.

2d. Their adaptation for generating steam, for domestic uses, and for the manufacture of iron.

3d. The position of this coal basin to command a market in competition with other coals.

4th. Your opinion of the situation of the tract being worked by this Company.

Very respectfully, yours,

H. C. FREEMAN, *Manager.*

SPRINGFIELD, ILLINOIS, June 20th, 1856.

H. C. FREEMAN, ESQ., *Civil Engineer and Manager L. C. M. Co.:*

DEAR SIR:—Your letter of inquiry in regard to the coals of the La Salle basin is received, and by direction of Gov. Matteson, I proceed to answer your interrogations so far as my knowledge of that coal-field will allow.

To do that in the most succinct and satisfactory manner, I send you, in tabular form, the analyses of some of the coals of this State which have been analyzed in the State laboratory, including most of those of the La Salle basin. It will enable you to make a comparison of the relative merits of the most important of our Illinois coals.

I also send you analyses of some of the Ohio and Pennsylvania coals, several of which are well known in the Chicago market; together with a table of a few foreign coals which bear a high reputation among manufacturers of iron. I do this because the iron hills near Lake Superior furnish an abundant supply of rich ore, which can be made accessible to your coals by means of the lakes and the Illinois and Michigan Canal.

Of your three workable beds, the lower one ranks highest in intrinsic value, for the uses to which common bituminous coal is generally applied. In quality the middle bed is scarcely inferior to the lower one, and, in my opinion, will be found of more value to miners on account of its geological position and greater thickness. The cannel coal in connection with that bed will compare favorably with most of our western coals of that class.

The upper bed coal will not bear transportation quite as well as those of the other beds, and on that account I think it probable that you may find it more profitable to convert it into coke than to send it to a distant market. All our northern and central railroads will soon be compelled to use coke, or the best quality of bituminous coal for fuel, and their demand, in addition to that for manufacturing purposes, can only be supplied from a few of our northern and central coal seams.

The position of the La Salle basin is not surpassed by that of any other in the West. It is connected with Lake Michigan and the Mississippi River by means of the Illinois River and the Canal. It is also intersected by the Illinois Central Railroad, giving a connection with both northern and southern markets; and by the Chicago and Rock Island Railroad, giving it access to markets east and west. Thus at no time need you fear an overstock in the market, as you can send your coals in all directions both winter and summer, and the demand will always be equal to the supply.

The situation of the lands of the Company which you represent, is such as to give you facilities on all the routes of transportation named.

The tract lies in the eastern part of the coal basin, and has the three workable beds of coal beneath its surface. The shaft sunk on the western side of the tract commands the whole of the coal contained in it, and will drain almost the entire tract without any extraordinary expense. Its situation alongside of the Illinois Central Railroad affords you the great conve-

nience for shipping to all markets on that road and its connections, while the Valley of the Little Vermilion gives you an outlet, in a short distance, to the Canal.

In short, you have the three beds as favorably situated for profitable mining, as in any other part of the basin.

I have thus answered your inquiries to the best of my judgment, formed after a careful and minute examination of the La Salle coal basin, and an accurate analysis of the coals by Mr. Henry Pratten.

Very respectfully and truly, yours, &c.

J. G. NORWOOD, *State Geologist of Illinois.*

COMPARATIVE ANALYSES OF ILLINOIS COALS WITH OTHER AMERICAN AND FOREIGN BITUMINOUS COAL.

Northern Illinois Coal.

Name of Coal.	County.	Specific Gravity.	Moisture.	Volatile Gases.	Carbon in Coke.	Ashes.	Carbon in Coal.	Color of Ash.
Watson's Mine,	Grundy,	1.259	9 0	36.5	47.8	6.7	51.8	Pink.
Turner's.* (Morris)	"	1.227	7.0	41 5	49.0	2.5	54.1	White.
Marseilles,	La Salle,	1.3144	5.0	40.6	33.4	21.0	47.0	"
Ottawa,†	"	1.2672	7.8	35.9	52.3	4.0	54.6	
La Salle Basin (Lower Bed,)								
Ireland's,	"	1.237	6 3	39.9	50.3	3.0	55.1	Grey.
Seeley's,	"	1.2234	8.0	34.6	41.4	16.0	53.0	Red.
Field & Rounds',	"	1.222	6.7	41.4	46 7	5.2	53 4	Red.
Hartshorne's,*	"		4.9	37.6	49 7	7.3	54.16	Brown.
Hitt's,	"	1.2989	4.5	42.4	40.3	12.8	47.5	White.
(Middle Bed,)								
Big Vermilion,	"	1.212	12.0	39.4	47.1	1.5	54.8	
Kirkpatrick's,	"	1.202	7.0	41.2	49.3	2 5	54.6	Grey.
Egleston's,	"		5.5	42.75	48.45	3.3	52.68	Grey.
(Upper Bed,)								
La Salle Coal Mining Co.	"		10.0	42.51	40.49	7.0	47.44	Brown.
Tiskilwa,	Bureau,	1.363	7.5	35.5	48.9	8.1	57.0	White.
Sheffield,	"	1.1936	7.0	40 5	47.5	5.0	53 4	
Aldrich's,	Henry,	1.261	6.0	37.1	49.9	7.0	54.1	Brown.
Kewanee,	"	1.232	9 0	33.2	52.8	5.0	58.2	Grey.
Loomis'. Wataga,	"	1.286	11.0	33.4	51.1	4.5	54.1	Pink.
Corcyran's,	R. Island,	1.2656	8.0	39.2	50 8	2.5	57.7	Black.
Carbon Cliff	"	1.2 7	7.0	36.7	52.8	3.5	55 8	White.
Thornton & Parke,	Mercer,	1.244	7.7	38.1	49.7	4.5	53 2	White.
Smith's,*	Warren,		6.1	37.0	51.7	5.2	54.55	
Tucker's,	"	1.227	8.0	36 8	51.0	4.2	57.0	Red.
McMurtry's,	Knox,	1.216	11.0	39.5	45.5	4.0	55.5	Black.
Kickapoo,‡	Peoria,		11.5	36.2	46.3	6.0	53.2	Grey.
Opposite Peoria,§	Tazewell,	1.263	5.4	38.0	48.6	8.0	52.0	Grey.

* Good Coke. † 1½ feet thick. ‡ Middle Bed. § Lower Bed.

Central Illinois Coal.

Name of Coal.	County.	Specific Gravity.	Moisture.	Volatile Gases.	Carbon in Coke.	Ashes.	Carbon in Coal.	Color of Ash.
Payne's, (in entry)	Vermilion,	1.2388	5.1	41.9	47.5	5.5	55.5	Grey.
Henson's.	"	1.311	9.0	34 5	50.0	6.5	58.3	
Lafferty's,	"	1.280	8.5	35 8	48.7	7.0	51.7	Grey.
Caruther's,	"	1.218	8.5	42.3	46.3	3.0	51.1	Grey.
Gilbert's,	"	1.218	8 0	43.4	45.6	3.0		
Butler's,	"		6.0	34.1	47.9	12.0	55.7	Grey.
Payne's, (outcrop)	"		8.7	37.4	43.9	10.0	50 83	Grey.
Barker's,	Scott,		5 5	37.3	52.2	5.0	54.8	Brown.
Sanders',	Sangamon,		5 6	42.54	42.86	9.0	50.11	
Jackson's,	Pike.		2.0	12 1	56.9	29 0	57.5	Grey.
Cartlidge's,	Madison,		8 3	36.9	45.01	10.6	50.83	Grey.
Grosbang's,	"		7.5	30 05	54.85	7.6	56.27	Brown.
Colchester,	McDonough,	1.290	5.4	35.3	56.8	2.0	60.10	
Caseyville,	St. Clair,	1 304	6.0	33.3	55.2	5.0	55 8	Pale Red.
Pfeiffer's,	"	1.293	8.5	35.8	51.2	4 5	57.5	Red.
Belleville,	"	1.268	5.5	39.5	49.6	5.4	54.6	Grey.
Jeffrey's,	Madison,		11.0	37.75	47.35	3.9	51.48	Grey.

Southern Illinois Coal.

Name of Coal.	County.	Specific Gravity.	Moisture.	Volatile Gases.	Carbon in Coke.	Ashes.	Carbon in Coal.	Color of Ash.
Du Quoin,	Perry,	1.285	8.5	40.4	48.1	8.0	59.6	Grey.
Schneider's,	Monroe,	1.246	6.7	36.2	52.6	4.5	58.7	White.
Murphysboro',	Jackson,		6.5	31 2	60.8	1.5	67.0	
Saline River,	Gallatin,							
Upper Bed,	"		2.6	39.8	56.1	1.5	58.5	
Second Bed	"		6.5	30.8	55.2	8.0	60.7	
Lowest Bed work'd,	"		8.0	32.8	55.2	3.7	63.1	
Spiller's,	Williamson,		6.2	36.9	54.9	2.0	57.5	
Eagle Creek,	Gallatin,		1.0	36.0	57 2	5.8	67.01	Grey.
Bowles',	"	1.303	2.0	37.8	53.2	7.0		White.

Analyses of American Coals, some of which are used in the West.

State.	Locality.	Name of Bed.	Specific Gravity.	Volatile Matter.	Carbon.	Ashes.
Pennsylvania,	Venango County,	Sandy Ridge,		43.20	49.80	7.00
"				52.78	29.54	17.68
"	Beaver County,			36.00	30.12	33.88
"	Crawford County,			38.75	59.45	1.80
"	Mercer County,		1.275	40.50	57.80	1.70
"	Orangeville,			43.75	53.45	2.80
"	Blossburg,	Coal Run,	1.371	16.40	75.40	8.20
"	"	Bloss' Coal,		32.80	62.80	5.20
Ohio,	Portland County,	Upson's	1.264	44.298	53.404	2.288
"	Jackson County,		1.283	47.827	49.882	2 221
"	" "		1.560	44.800	39 950	14.620
"	Pomeroy,			18.70	76.70	4.60
"	Briar Hill,		1.320	38.18	58.41	3.46
Indiana,	Parke County,	Foundry,	1 219	21.00	75.00	4.00
"	Vermilion County,		1.270	39.00	52.00	9.00
"	Vigo County,		1.240	27.50	70.00	2.50
"	Sullivan County,	Lick Fork,	1.240	28.00	70.00	2.00
"	Terre Haute,		1.240		50.80	
Iowa,	Duck Creek,		1.270	44.00	48.50	7.50
Missouri,	Calloway County,	Mammoth Vein,	1.250	34 20	50.78	15.02
"	Cote-sans-dessein,	Mastodon Vein,	1.252	34.06	40.18	15.18

Analyses of Foreign Coals, used in the manufacture of Iron.

Country.	Locality.	Name of Bed.	Volatile in Coking.	Carbon.	Ashes.	Color of Ash.
England,	Forest of Dean,	Linderford,	36.00	62.	2.	Red.
"	Parkend,	"	39.00	58.5	2.5	Ochre.
"	Coleford,	High Delf,	32.08	63.72	4.25	Red.
"	Starkey,		36 72	61.58	1 75	Red.
"	S. Staffordshire,	New Mine Top,	4[illegible].100	52.775	2.125	Pink.
"	"	Fire Clay,	46.35	51.40	2.25	Buff.
"	Bentley,	Ten Yard,	34.18	63.57	2.25	White.
"	Lane End, (N. Staffordshire.)	Bassey Mine,	38.70	58.30	3.00	Pink.
"	Lane End, (*best furnace*,) N. Staffordshire,		32.30	65.20	2.50	White.
"	Golden Hill,	Spendcroft,	39.58	58.67	1.75	
"	"	Little Row Bed,	34.53	62.47	3.00	Grey.
"	Shropshire,	Randle Coal,	32.81	64.19	3.	White.
"	"	Double Coal,	41.38	57.87	.75	Fawn.
North Wales,	Brymbo,	Three Yard,	35.70	6[illegible].70	1.6	Light.
	"	Brassey Vein,	34.100	64.582	1.318	Grey.
England,	Churchway,		35 67	60.33	4.	Brown.
"	"		34.740	64.135	1.125	Fawn.
"	S. Staffordshire,	Corbyn's Hall, (Ton Coal.)	40.6	51.9	7.5	Grey.
"	"	Corbyn's Hall, (Heathing Coal,)	43.33	54.17	2.50	Buff.
"		(Bottom Vein,)	32.	62.870	5.125	Pink.
"	" Bentley,	(5 feet Splint Coal,)	45.83	49.42	4.75	Red.
"	N. Staffordshire,	Ten Feet Coal.	39.11	58.89	2.	Grey.
"	Golden Hill,	Great Row Coal,	37.70	60.30	1.75	Grey.
"	"	Little Row Coal,	34.53	62.47	3.	Grey.

COAL BURNING BOILERS.

A brief description of the various forms of coal burning boilers now in experimental and practical use, will be interesting.

Boardman's Boiler.—The fire-box is of the ordinary kind. The waist of the boiler is nearly of the same shape, in section, as a flat-bottomed smoke-box,—such as on the Taunton, Rogers or Norris engines. A shaped flue extends from the upper part of the fire-box throughout the length of the boiler. In the flat-bottomed sheet of this tubes are set, extending down to the flat bottom of the boiler. Under this is a pan or bottom, serving as a flue for the smoke. This flue or pan continues for the whole length of the bottom and enters an ordinary smoke-box at the front end. It is seen that the fire goes through the tubes, while the water is around them, as in the ordinary boiler.

Phleger's Boiler.—We are not quite sure but that Mr. Phleger's later improvements may have dispensed with some features contained in his boiler, as seen by us last winter. But presuming there has been no change, the following will answer.

The water space around the fire-box extends also under the bottom. The grate is made of tubes filled with water, and opening into the water space of the fire-box. About two feet back of the tube sheet is a diaphragm or water-bridge, rising from the water bottom, say three feet high. From the crown of the fire-box, and within perhaps 18 inches of the tube sheet, another diaphragm or water-bridge also comes down about one foot,—this bridge or water space being inclined toward the tube sheet so as to deflect the flame and sparks downward. Both water bridges, of course, go entirely across the width of the fire-box. They protect the tube sheet from the direct blaze from the coal, and prevent particles of coal from being drawn through the tubes. It is proper to say that in front of the main water-bridge, or between that and the tube sheet, there is no water bottom, but only a door through which ashes and cinders can be removed. The fire-box is enclosed, however, practically air-tight, and the draught supplied by a fan, worked by the exhaust steam. The barrel and tubes of the boiler are the same as in any ordinary locomotive.

Dimpfel's Boiler.—The fire-box is of the common kind, except so far as relates to the fixing of the tubes. From the front side of the fire-box, in the usual position of the tube sheet, a large flue opens, and extends nearly through the whole length of the boiler, leaving only an ordinary water space of 3 or 4 inches around it, and against its forward end. From near the forward end of this flue, a chimney opens up through the water and steam room above it, and is continued, in the usual form, above the waist of the boiler.

The tubes, which we are now to describe, carry water, and are surrounded by fire. These tubes are set in the *crown* of the fire-box, below which they are bent with a round bend, and thence run horizontally through the main flue or combustion chamber, opening again into the water space at the front end of this flue. These tubes are of iron, 1 1-4 inches in diameter outside.

Winans' Boiler.—This is in the most general use of any for burning both hard and soft coal. The principal peculiarity is in the fire-box. The grate is very long, say seven feet. The grate bars are cast very heavy, two together in one casting, and a shank comes out from each, through the back of the fire-box, and in this shank is a round hole through which a rod or handle is inserted to stir the grate, and loosen the coal. All along the width of the furnace, and down to the grate, a wide grated door is fixed. The lower edge of this door swings just even with the top of the grates. The grating or openings through this door are upright slots, say 5 by 1 1-2 inches, quite near together, and for the double purpose of admitting fresh air constantly to the back side of the fire, and for inserting a poker to stir the coal. Above this grating is the common door for firing. The top of the furnace slopes in the length of the boiler, the fire-box being shallow at the back sheet, and deepest at the tube sheet. About midway on this slope, an opening is made through

the crown of the fire-box, this opening being covered or exposed by a sliding cast iron door. Around this opening, a hopper or curb is raised up—large enough to hold coal, perhaps enough for once firing. A loose, swinging cover is placed on the top of this curb. When running, the back doors of the fire-box are seldom open, but this hopper is filled, and its contents then dumped (by withdrawing the sliding door) over the grate.

It will be remembered that the fireman's footboards are on the tender, and that there are two decks or landings, one over the other—from one of which the lower doors may be fed, and from the other of which the coal-hopper may be filled.

The ash pan has a tight bottom, so as to hold three or four inches of water,—into which the slag and loose coals drop and are extinguished. In the smoke box there is a variable exhaust. The chimney is straight,—has no deflecting cone, and only a grating over its top. For all the other coal boilers named, the chimney is mostly of this kind.

Millholland's Boiler.—The fire-box, variable exhaust and chimney are essentially like Winans'. There is, however, no coal feeding hopper on the back of the fire-box, as the fire-boxes on these boilers are square,—five feet each way. The peculiar feature of these boilers is the combustion chamber. This is a sort of smoke-box, placed within the boiler, surrounded by water and about five feet from the fire-box tube-sheet. One set of tubes lead from the fire-box into this chamber and another set lead from this to the smoke-box, there being thus two sets of tubes and four tube-sheets. A square leg comes down from this combustion chamber, through the bottom of the boiler, there being a water-space around this and a door on the bottom. Through this leg, a man may get into the combustion-chamber to set and caulk the flues. A few of the stay bolts in this leg are hollow, to admit air to complete the combustion of whatever gases have not been already burned over the grate.

O. W. Bayley's Boiler.—The novel feature is contained in the fire-box. This is divided into three chambers or compartments; a water space, four or five inches thick, passes from near the top of the back side of the fire-box, sloping downwards to below the tubes on the front side,—thus dividing the fire-box into an upper and lower chamber. The lower part is again divided in its width by a fore-and-aft vertical water bridge, connecting at top with the water space above described. A square opening is made through the vertical water space, so as to open the two lower chambers into each other. Two openings are also made and covered by sliding doors, in the sloping water space above. The fire doors open, one each into the lower chambers.

The mode of working is this. Fire is first made on the grates on both sides, or in both of the lower chambers, and both of the sliding doors above are opened. After the coal gets well to burning and when fresh coal is applied, the fire-box is managed as follows:—The left hand sliding door only, upon the sloping water space, is left opened. The right hand fire door, or feeding door is also opened, and coal applied to the right hand grate. The flame and gas from this coal pass through into the left hand lower chamber, over the burning coal on that side, thence up through into the upper chamber and off to the tubes. The firing is then reversed by shutting the left hand sliding door and opening the right hand one. Coal is then put upon the left hand grate. The gas passes through into the right hand lower chamber, over the hot fire, up into the upper chamber and again off through the tubes. By this means, the coal becomes partly coked before it is finally burned, and the gases are probably quite entirely consumed.

Latta's Boiler.—A recent application of this boiler by the Boston Locomotive Works has attracted some attention. The furnace is a square chamber, seven or eight feet high and with a water space all around it. The water is contained in coils of tubing. A length of iron pipe, say of two inches diameter, is laid across the furnace above the grate. This pipe has a return coupling on one end, and another length of pipe is brought back, and so on for a few courses in height. Then the return couplings divide or throw out each

two return nozzles, thus doubling the area of tubing through which the steam and water circulate. After a few courses of these double tubes, the return couplings again divide and send back four lengths of tube, side by side, and all connected with the original tube. And after a few courses of these quadruple tubes, the couplings again divide and send back eight lengths of tube, with which number the pile is completed. As many separate and complete piles, or courses, of this kind, are laid up, as will occupy the whole width of the fire-box. These piles are connected at top and bottom with the water space of the furnace around them, and the heat of the fire circulates freely through them. The chimney surmounts the whole.

M. W. Baldwin & Co.'s Boiler.—Perhaps no other form of boiler in successful use, has been made to burn coal with so little change of form and structure from that of the common kind. The fire-box is five or six feet long, the back of the fire-box and fire-door the same as for an ordinary wood-burner; the grate is stationary and of the common pattern, only heavier. The boiler has a variable exhaust and open chimney. About the only peculiar feature is a horizontal row of two-inch iron tubes running across the width of the furnace, just under the crown. These give an increase of heating surface and quicken the circulation of the water.

There are many other varieties of boilers now in experimental use, but we are not able to furnish as full particulars of them as we would wish. From those we have mentioned, leading ideas may be had of the forms of boilers already most prominently before the public.—*R. R. Record.*

COAL BURNING LOCOMOTIVES.

After a variety of experiments, A. S. Adams, master machinist of the Boston and Worcester Railroad, has now in operation a freight locomotive adapted to burning coal, which seems so well to meet the wants of the road that all the engines of the Company, used in drawing freight, are to be altered to the same style. The engine in question, the "Bison," has one of the Delano grates, by which the coal is forced from the bottom up through the bed of the fire. This grate is but 38 inches in length, but by its manner of operation all the gas is consumed, and the top of the bed of coal is kept always ignited, no new coal ever being thrown upon it. The draft is also kept good and is never obstructed by clinkers. Careful estimations of the precise cost of running this engine have been made, and it appears that with it, for 12 cents per mile, a common freight train can be run and make the usual speed. A wood engine to run the same train costs 30 cents per mile. The saving, as will be seen, is very great. The cost of altering a common wood engine to fit it for burning coal is but $150; and as we have before remarked, the Worcester Company have decided to have all the freight engines converted into coalers as speedily as possible.

IRON AND ZINC.

STATISTICS OF IRON MANUFACTURE.

During the six months ending December 31st, 1855, the importation of Pig iron from all foreign ports reached only 29,839 tons. This is less than one third of the amount imported during the previous twelve months. Since the commencement of the present year the production of Pig iron east of the Alleghanies exceeds the quantity manufactured during the same period of any previous season.

It is computed that 280,000 tons of Pig iron will be produced in the West during the present year—this, of course, includes Western Pennsylvania. From the districts of Alleghany, Hanging Rock, and Clarkesville, about 200,000 tons will be sent to market. There will be a decrease of Charcoal Pig in the present year, when compared with the production of 1855, of 55,000 tons. The product of new coke and raw bituminous coal furnaces will, however, make good at least 15,000 tons of this deficit. The amount of Anthracite Pig consumed in the West in 1855, was 33,000 tons. There will be an increased amount needed during the present year.

According to a statement in the *Iron Master's Review*, the following is the quantity of iron consumed in the places named in the West:

Cincinnati,	40,000 tons
Covington and Newport,	8,000 "
Pomery,	5,600 "
Iron and Hanging Rock,	13,000 "
Portsmouth.	10,000 "
Dayton,	4,000 "
Louisville and New Albany,	12,000 "
Wheeling,	30,000 "
Pittsburg,	120,000 "

The product of American rails this year promises to be at least 145,000 tons, and may possibly reach 175,000 tons. Brady's Bend works have commenced full operations; Cambria and the Lackawanna have added considerably to their puddling capacities.

By reports from sixty-one railroads, it is ascertained that they have an aggregate length between termini, of 5,840 miles, and of sidings and second tracks, 974 miles; making a total of 6,814 miles of track. These roads are to have an addition in 1856, of 873 miles, of which 300 miles is for renewals; the remainder, 573 miles, is for additional sidings and extensions. These sixty-one roads are laid with rails having an average weight of 91.3157 tons per mile, or 58.11 pounds per yard.

The weight of the whole of the old track, 6,814 miles, is	622,225 tons
The weight of the track to be laid this year, 873 miles, is	79,718 "
The weight of old rails to be renewed, 300 miles, is	27,394 "

If we estimate comparative figures from the aggregate miles of railway which were in operation in the United States, December 31, 1855, by the figures accurately obtained and given above, we have the following results:

Total number of miles of distance between termini,	21,440 miles.
Miles of sidings and second track,	3,749 "
Total number of miles of track,	25,189 "
Extensions, renewals, and additional sidings, to be laid in 1856,	3,861 "
Renewals of track in 1856,	1,155 "
Total weight of rails in 25,189 miles of track, 91.3 tons per mile,	2,299,755 tons.
Weight of rails required for 3,861 miles, in 1856,	306,989 "
Weight of old rails from 1,159 miles,	105,561 "

We have no satisfactory data by which to judge of the extent of new railways to be opened this year.

Statement exhibiting the Quantity and Value of Railroad Iron imported into the United States, from the 30th of June, 1839, *to the 30th of June,* 1855:

Years ending.	Cwt.	Value.	Tons. cwt.
June 30, 1840......	581,833	$1,569,884	29,091 13
June 30, 1841......	465,069	1,064,960	23,253 9
June 30, 1842......	499,400	1,093,079	24,970 0
June 30, 1843......	193,098	853,921	9,654 18
June 30, 1844......	311,544	446,782	15,577 4
June 30, 1845......	436,249	637,514	21,812 9
June 30, 1846......	117,943	281,077	5,897 3
June 30, 1847......	270,733	680,433	18,536 13
June 30, 1848......	589,799	1,219,185	29,489 9
June 30, 1849......	1,383,265	2,252,146	69,163 5
June 30, 1850......	2,840,733	3,783,084	142,036 13
June 30, 1851......	3,772,516	4,901,453	188,625 16
June 30, 1852......	4,912,510	6,228,794	245,625 19
June 30, 1853......	5,979,904	10,426,037	298,995 4
June 30, 1854......	5,657,339	12,020,309	282,866 19
June 30, 1855......	2,550,327	3,993,900	127,516 7
Total, 16 years.....	30,562,257	$50,912,513	1,528,112 17

Assessed value per ton, and average cost per year:

June 30, 1840	$53 96	June 30, 1848	$41 38
June 30, 1841	45 80	June 30, 1849	32 56
June 30, 1842	43 77	June 30, 1850	26 32
June 30, 1843	37 18	June 30, 1851	26 08
June 30, 1844	28 68	June 30, 1852	25 32
June 30, 1845	29 27	June 30, 1853	34 36
June 30, 1846	47 66	June 30, 1854	42 46
June 30, 1847	51 01	June 30, 1855	31 39

Average cost of the whole per ton......$32 67

MALLEABLE IRON.

By recent arrivals we have accounts of important improvements in the manufacture of malleable iron and steel, from which a great revolution appears to be anticipated. The descriptions which have appeared are very numerous, and we annex such as appear to give the most complete view of the whole subject. The London Mining Journal thus briefly describes them:—

Mr. Henry Bessemer, of Queen Street Place, has patented some improvements in the manufacture of cast-steel, which consists in constructing a furnace having a long rectangular chamber, the mouth of which is on a level with the floor of the foundry; the sides and ends of the chamber are vertical and parallel to each other, and the bottom of it is formed into an elevated ridge, which extends the whole length of the chamber. This ridge is formed by the apex of a pointed arch, which is made below it, and is called the cave. Along each side of the furnace there are arranged fire-bars, which extend from the lower parts of the ridge for some distance up the vertical sides of the chamber, there being no fire-bars at the bottom of the chamber; the central part of the ridge is flattened, and there are formed in it, at equal distances, several holes, over or into which the lower end of the pots or pot-stands is placed, so as to insure the proper position of the pots. The top of the chamber is covered with large fire tiles, or with an iron frame, in which fire bricks are fixed, several openings being left to afford access to the pots. Along one side of the furnace there is a row of square holes, leading into a chimney of sufficient height to insure a powerful draught. The pots preferred being of the form known as skittle pots, with a lid to each, and a tapping hole made in the bottom of them. The pots should be placed on a stand some 4 or 5 inches in height; or the lower parts of them may be elongated, so as to form a stand, and be of such a size as to fit the holes in the top of the ridge, so that access may be had to the underside of the pots from the cave below. The fuel used should be hard oven coke, which is supplied from the opening on the upper side of the furnace, the fuel filling up the spaces round about the pots, and rising as far as the top of them. The fire-bars are placed below the foundry floor, and the air for combustion is supplied from the cave below the furnace, which, when the draught of the chimney is alone depended on, must have a free communication with the outer air; but, in order to obtain a powerful combustion in the furnace, the cave below is usually closed, and a blowing fan employed, by means of which air is forced into the cave, and thus the draught of the furnace assisted. Access is obtained to the caves by means of a revolving door, which acts as a valve, and will allow a workman to walk through it on one side of the axis (which is vertical), while at the other side a small portion only of the compressed air escapes, the revolving door being in part enclosed in a cylindrical casing. At a convenient distance from this furnace a finery furnace is constructed, or a common cupola blast furnace, in either of which the pig-iron intended for conversion into steel is melted. From time to time the finery or cupola furnace is tapped, and the molten iron run into a ladle; the metal is poured from thence into the pots, where its high temperature will be still further increased. Above the furnace is an iron pipe, covered with brickwork, or otherwise protected by a bad conductor of heat. Into this pipe highly-heated atmospheric air alone, or air and steam mixed, or steam alone,

also highly heated, is forced under a pressure exceeding that of a column of metal equal to the depth of fluid metal in the pots. Although the action of highly-heated air or steam produces a more rapid change in the quality of the metal than cold air or steam of low pressure, and for that reason is to be preferred; it will, nevertheless, be understood that air less heated, or of the ordinary temperature of the atmosphere, and steam of the temperature due to a low pressure, may be used in all cases where it is desired to do so. The flow of air or steam into the pipe is to be regulated by a valve under the control of the workmen who attend the furnace. A small movable pipe is placed vertically over the centre of each pot, and passes freely through a hole into a branch of the air-pipe above, and is capable of sliding downward as far as the bottom of the pot, or nearly so. In order that the pipes, when they are withdrawn from the pots, may be moved on one side, and thus afford free access to the furnace mouth, they are constructed accordingly. The pots having been charged with molten iron, air or steam is passed through it, subjecting every part of it to the chemical action of the gaseous products passing through it, and it becomes steel.

On the other hand, the London Review goes into a very extensive sketch of the entire proceedings, which perhaps will be more acceptable with those less familiar with the manufacture of iron:—

When it was announced at the late meeting of the British Association, that a paper would be read on a new method of converting cast into malleable iron without the use of fuel, the intelligence was received by many with a smile of incredulity, and not a few "practical men" went to the meeting of Section G, expecting to be entertained by the visionary schemes of some ingenious but idle enthusiast. Their expectations were utterly falsified. Conviction was forced upon minds from which no ready assent could have been hoped; a great invention was lucidly and unostentatiously propounded; and men who went prepared for an exhibition of temerity, if not of folly, remained to express their concurrence in the graceful tribute of admiration paid by Mr. Nasmyth to one of the greatest discoveries of the age. Every one felt, after hearing Mr. Bessemer's paper, that, if any reliance could be placed upon the facts stated to the Association, a new era was at hand in all those numerous and important branches of manufacturing industry which concern the working of wrought iron and steel. Without further reference to the paper communicated to the association, we will now describe what we have seen at Mr. Bessemer's premises at Baxter House, leaving our readers to say whether we have overstated the importance of the subject.

It is necessary to premise that common cast iron contains somewhere about 4 or 5 per cent. of carbon, as well as a variable quantity of silicium and other earthy basis, phosphorus and sulphur. The object of every process for making malleable iron is the separation and removal of these foreign substances. The best malleable iron contains about ½ per cent. of carbon; but the process of extraction is difficult and expensive. The fusibility of iron depends upon the quantity of carbon present; and no commercially available method has till now been discovered by which iron, after parting with a very large proportion of its carbon, can be brought to remain in a state more nearly approaching fusion than that of a pasty mass. Steel is produced from iron from which the carbon and other impurities have been extracted, by a tedious and costly process, the object of which is the restoration of a portion of the carbon which previous processes have removed. Steel contains, according to the purposes for which it is wanted, from rather more than ½ per cent. to rather less than 2 per cent. of carbon. Malleable iron—or iron comparatively free from carbon—is usually produced, in this country, in the following manner:—

The melted iron, as extracted from the ore in the smelting or blast furnace, is run out into bars a few feet in length, technically termed *pigs*. These pigs, when cold, are removed from the sand-holes into which they were run, and transferred to a second furnace, called "the fining furnace," where they

are again reduced to a state of fusion, and finally, the mass thus produced is placed in a third furnace, where it undergoes the process of puddling. Omitting all matters of detail, the essential part of this operation is the reduction of the iron to a pasty mass, which is stirred and rolled about by the workman until a large ball, or "bloom," of iron, weighing from 60 to 70 pounds, is conglomerated at the end of the rod with which he works, and is adjudged to be in a fit state for the final process. It is then withdrawn from the fire, and taken to a "tilting hammer" and a pair of squeezers, or to a Nasmyth's steam forge, where it is subjected to a very heavy pressure, and a quantity of melted slag and refuse, mixed with the puddled iron, squeezed out. For the purpose of our present comparison we need follow the process no further. Other methods of producing malleable iron directly from the ore are in use in various parts of the Continent; but they are extremely expensive, require a rich ore and a very pure fuel, are only applicable upon a small scale, and sacrifice a very large percentage—in some cases from 40 to 50 per cent—of the metal.

Of all our more important mechanical operations, perhaps puddling is the most imperfect and unsatisfactory. It is very expensive, both from the quantity of fuel consumed (which is about equal to the weight of metal treated) and the severe nature of the labor required. During the recent hot weather it was found necessary to stop nearly all the Staffordshire puddling furnaces—two men having fallen dead at their work. The result is the production of an iron so far from being chemically pure that it is astonishing how much we have been able to effect with so imperfect a material. From the immense demand for iron which has prevailed for some years past, and the stimulus that has thus been given to the production of increased *quantity*, the *quality* has very seriously deteriorated. The difficulty experienced by the Government during the last war in procuring iron of a quality suitable for the purposes of warfare is too well known to need more than a passing reference.

Mr. Bessemer's experiments have been conducted upon the pig-iron. He proposes that, for the purposes of manufacture, the smelted iron, as it leaves the blast furnace, shall be run immediately into the converting vessel presently to be described; but, for the purposes of experiment, it has been more convenient to melt down pig-iron, as the metal is much sooner reduced to a state of fusion. The *experiment*, therefore, takes up the process at the point at which the metal is ordinarily placed in the fining furnace. It must be remembered, however, that one important end answered by his invention is to do away with the consumption of fuel required for this intermediate process. The "converting vessel," where the change of the melted metal from ordinary cast iron or steel to malleable iron is to take place, consists, externally, of a cylinder of iron, surrounded, near the bottom, by a hollow ring—an annular pipe, in fact—of the same metal, communicating with five small "tuyere" pipes, placed at equal distances round the cylinder. These pipes are carried through the outer and inner structure of the vessel, and each of them enters the chamber within, near the junction of the side with the floor, by an aperture about three-eighths of an inch in diameter, protected by a coating of the best fire-clay. The external cylinder is lined with a thick lining of fire-brick, and the internal structure consists of two chambers, or stories, communicating by a small cylindrical opening in the centre. The lower chamber, into which the melted iron is introduced, is a simple cylinder—the upper chamber has a floor inversely arched, so that any melted metal forced up through the opening from the lower chamber may trickle back again, and the roof is in the shape of a cupola or dome. Two apertures, a few inches square, placed opposite to each other between the floor and the top of this chamber, communicate with the external air. A powerful blast, worked by a small engine, can be let into the hollow ring which girds the outer cylinder, and thence, of course, enters the lower chamber through the tuyere pipes. A hole at the bottom of the chamber, secured in the usual manner, furnishes the means of tapping the vessel and running off the produce into the moulds prepared for it.

When every thing is ready for the operations to commence, the blast is set

on to blow into the converting vessel—the melting furnace is tapped—and the melted iron, of the usual deep orange tint, pours slowly down the channel into the lower chamber of the converting vessel, through an aperture which is then closed up and luted. The pressure of the blast is about 9 or 10 pounds to the square inch—strong enough to force the air completely through the superincumbent mass of fused iron, and out through the apertures near the top of the vessel. As the action is continued, every particle of the melted metal is brought in turn into contact with a stream of air. To use the language of chemistry, an energetic combination takes place between the oxygen of the air pumped in and the carbon mixed with the iron. In popular language, fire, instead of being supplied externally round and about the mass of iron, is kindled and sustained throughout every particle of the liquid metal. A heat is thus generated, vastly greater than that which can be supplied by mere external combustion. What is taking place is indicated by the tongues of flame which, in two or three minutes, begin to shoot forth from the apertures in the vessel, and which gradually increase in body and intensity until the whole mass is in a state of agitation, almost like boiling water—the difference being, however, that the agitation is caused by the external force of the air blown rapidly and continuously through the liquid iron, not by the conversion of the substance itself into an expansible vapor, as in the case of genuine ebullition. However, this state may very fairly be called "the boil," and it is indicated by the blowing out, through the apertures, of large quantities of melted slag—the refuse which is squeezed out of the puddler's *bloom* under the action of immense pressure, but which is here driven off simply by the action of the blast, because, being much lighter than the iron, it rises to the top, like scum upon the surface of water, now that the metal is in a state of perfect fluidity. It is supposed that at this period a very important change begins to take place, and that that part of the carbon which is in a state, not of mechanical mixture, but of chemical combination with the iron, is now compelled, by the agency of the increasing heat, to part from the metal, and yield itself a captive to the superior affinity of the oxygen. This "boil" takes place from fifteen to twenty or twenty-five minutes after the commencement of the process, and continues with more or less violence until all the carbon is burned out. The moment that this is effected, and that no more carbon, or only a very small quantity remains, the metal must be run out, otherwise the action of the air would cool the metal, and make it set hard with great rapidity. It may be run out into molds of any size or shape, but the most advantageous form is that of a deep and narrow mold, as then the slag which has not been already removed, and which comes last out of the whole at the bottom of the converting vessel, lies in a thin cake at the top of the casting, and is easily taken off by a pair of shears.

It will be obvious that one principal feature in the process is, that the operator deals with the metal in a state of perfect fluidity—a desideratum hitherto unattainable with iron containing only a small quantity of carbon. Hence it can not merely be procured in masses of any size (whereas the puddler can only produce 60 or 70 lbs. in a lump,) but it will possess the distinguishing character of all fluids—it will be perfectly homogeneous. The texture, composition and quality will be the same throughout every part of the mass. That the fluidity is really greatly increased, notwithstanding the subtraction of the carbon, is shown by the fact that it is found desirable to diminish the power of the blast from 9 to 10 pounds to about 5 pounds during the latter part of the process, as well as by the rapidity with which the metal runs out of the furnace, and its brilliant whiteness. It is impossible to overrate the advantage of having a really homogeneous product. In large masses of malleable iron, procured in the ordinary way by welding together a number of the puddler's *blooms*, there often occur small knobs and fragments of metal much harder than the rest, and many manufacturers consider soft malleable iron quite as trying to their tools as hard steel, from the unexpected increase of resistance suddenly offered by particular parts of the mass, and the conse-

quent unequal strain upon different portions of the machinery. The greater the mass required, the greater the difficulty of obtaining a metal upon all parts of which equal reliance can be placed; and hence where a very heavy strain, in a direction different from that of the fibre, is expected, strength is often obliged to be sought in an enormous thickness of material. The prodigious weight of anchors is rendered necessary by the impossibility of calculating accurately the strength of the metal in any particular part, so that the size of the whole must be increased to meet the chance of a bad piece of metal occurring here and there. One of Mr. Bessemer's numerous patents is for the application of his invention to the construction of anchors, in which he hopes to attain equal strength with a greatly diminished weight.

It is hardly necessary to point out the enormous saving in labor and fuel effected by the new process, especially in the manufacture of steel. Mr. Bessemer believes that steel, such as is now worth from £50 to £60 a ton, may be produced at a cost to the manufacturer of less than £10 a ton. In the manufacture of malleable iron, also, the saving will be very great, though less than in the case of steel. Indeed, one of the results of the invention will be the curious anomaly that steel will be produced at a little less risk, and therefore at a little less cost, than malleable iron; for it is obvious that, by tapping the furnace *before* the complete combustion of the carbon has taken place, steel will be produced instead of iron. Practice and experience will, no doubt, in time enable the workmen so to regulate the operation as to produce to a nicety any particular quality of iron or steel required; but until this practical knowledge has been gained, there will be some difficulty in calculating the exact length of time to be occupied in the conversion. If, therefore, the process should be continued a little too long for steel, malleable iron will be obtained—if it be continued a little too long for malleable iron, the metal will be set in the furnace. "The boil" appears to be the critical period. Whatever be the time occupied in arriving at "the boil," it is found that from twelve to fifteen minutes are requisite to produce malleable iron, and from seven to twelve minutes to produce the different qualities of steel.

How effectually the carbon can be removed is shown by an analysis of a chance specimen of Mr. Bessemer's malleable iron, made by Dr. Henry, who, we believe, was strongly inclined to doubt whether the process could really be so successful as it was stated to be. He found the quantity of carbon present to be less than 1-30th per cent—or less than 1-3000th part of the weight of the metal. Of silica, a trace merely was found. By the application of means already well understood, the sulphur and phosphorus will be as completely removed. A considerable portion of both is driven off without the use of any means for that special object; and by treating the melted metal with proper substances, these impurities will be withdrawn. The difficulty which Mr. Bessemer has applied himself to solve, and which he has solved, is the complete separation of carbon and the earthy bases. Apart from the cheapness and facility of his process, he has been able successfully to grapple with the half per cent. of carbon which puddling can never get rid of.

The process, as described above, is open to a serious objection. The blast must be kept up to the last, or the melted metal would run into the tuyeres, and spoil the blast apparatus. Hence the air is being driven through the metal up to the very moment that it ceases to run out of the vessel; and the ingots produced are consequently very porous and full of air-bubbles. With malleable iron, this is of no importance, as it would always be rolled while in a state not far from fusion, and the air would be completely squeezed out, as the slag is squeezed out of the puddled ball. But cast steel would be useless if porous—a difficulty which is met by an ingenious modification of the converting vessel. It is slung horizontally at the end of two cranks, which, by means of a counterbalancing weight, can easily be turned through any angle. The blast is admitted by a pipe passing through the axle of one of the cranks, and thus revolving with the converting vessel. The tuyeres enter the converting vessel by a series of apertures forming a horizontal row. The cylinder

can thus be made to revolve round the axis of the crank without turning upon any axis of its own; and thus the apertures of the tuyeres may be raised till they are brought above the surface of the metal. The blast can then be turned off and the agitation of the metal allowed to subside. Iron melted by existing processes sets in about three or four minutes; but Mr. Bessemer finds that he can allow it to stand for ten or twelve minutes—a period quite sufficient to allow all the air-bubbles to escape—and the cylinder may then be raised still further, and the metal poured off as gently as may be requisite, through a spout at the top or in the side of the vessel. The quality of the steel produced admits of no doubt. A fragment broken off from an ingot cast when we saw the experiment, was compared with a fragment broken off from the end of a file. It was harder, and far finer in the grain.

The experiment in question was conducted with six or seven hundred weight of Yorkshire iron of a common quality. An ingot of six hundred weight was produced in one piece in about 25 minutes. There will be no difficulty in producing masses of any size or shape. The size of the converting vessel and the number of tuyeres may be increased to any requisite extent. The blast need not be increased in strength, as it will only be necessary to enlarge the area of the floor of the vessel, so that the iron may not rise to a height of more than 8 or 9 inches. The loss was about 18 per cent; but of this a considerable quantity might be recovered, as the slag blown out during the boil contains about 50 per cent. of iron, in the shape of little globules, like shot, set in the slag. It is extremely porous, and crumbles to the touch, so that it might be broken up, and the iron separated by washing, with little difficulty and labor. In the ordinary puddling process, from 17 to 25 per cent. is lost, and in the Catalan and Corsican processes, not only is a weight of charcoal consumed from three to seven times that of the iron produced, but 5-18ths, or about 38 per cent. of the metal is sacrificed to secure the purity of the remainder.

Mr. Nasmyth tried some years ago to decarburize cast iron by blowing steam into the melted metal. This attempt failed, as the separation of the oxygen from the steam exhausted so much of the heat of the metal that the heat evolved in the combination of the oxygen with the carbon in the iron was insufficient to compensate the waste; and the iron was cooled instead of being heated. With the freedom from jealousy which marks a truly great mind, Mr. Nasmyth paid, as we have said, at the late meeting at Cheltenham, a graceful tribute to the importance of the invention, and spoke in terms no less honorable to himself than to Mr. Bessemer, of the ingenuity of the process and the vastness of the results to which it would unquestionably lead. Mr. Bessemer, on the other hand, derives from the experience of Mr. Nasmyth the important knowledge that, by the joint use of jets of steam and blasts of air, he will be able to regulate with the utmost nicety the amount of heat generated and the rapidity of the progress.

It is difficult to assign any limits to the importance of an invention whose influence will be felt throughout the civilized world in an improved quality and diminished cost of one of the great staples of modern industry. The first axiom of the iron trade is demonstrated to be a fallacy; and, to a mind familiar with the subject, the magnitude of the change cannot be more emphatically expressed than in the simple proposition that the ancient and fundamental antagonism between the terms cast iron and malleable iron has ceased to exist; for malleable iron will now always be cast. It is impossible to doubt the truth of the opinion modestly expressed by Mr. Bessemer, that others will improve on his invention, and that his process will not receive its full development for many years to come. There is no country in which its influence will be as extended as our own, in which so large a portion of the community is engaged, directly or indirectly, in arts connected with the manufacture of iron and steel; but there are others where its effects within a narrow sphere will be yet more striking, and yet more welcome. In some countries, where malleable iron is produced direct from the ore, the consumption of char-

coal has become matter for serious alarm. In Sardinia it has long been to many reflecting minds, a subject of grave doubt whether the benefits to be derived from the development of this branch of industry were not more than outweighed by the wholesale destruction of the forests for fuel. We are glad to learn that Mr. Bessemer has not only secured the legitimate reward of his industry and ingenuity by the grant of patent rights in almost every part of Europe, but that, alive to the greatness of his invention, he has resolved to adopt a wise and liberal policy in the grant of licenses, and to place the use of his process within the reach of all persons who may be desirous of availing themselves of its important advantages.

ANALYSIS OF LAKE SUPERIOR IRON ORE.

Extract from the Register of the Assay Office, Paris, May 22d, 1856.

"Ecole des Mines," No. 2001.

Specimens of Iron Ore from the neighborhood of Marquette, Lake Superior, Michigan, given by G. W. Burr. No. 1, St. Clair and Smith mountain. Oxide of iron, somewhat micacious. Not magnetic.

No. 2, St. Clair and Smith mountain. Anhydrous peroxide of iron. Compact with magnetic ore.

No. 3, St. Clair and Smith mountain. Oxide of iron. Slightly micacious. Not magnetic.

No. 4, near Marquette. Oxide of iron in grain and sheety, magnetic ore.

No. 5, Eureka mine. Red oxide of iron with some ochre.

No. 6, Cleveland mountain. Specular ore,—Crystalline.

No. 7, Slaty or steel ore from Jackson and Cleveland mountains. Specular ore with quartz.

No. 8, Jackson mountain. Specular ore—crystalline. Same appearance as No. 6.

No. 9, Fine granular ore of Cleveland and Jackson mountains. Specular—compact.

No. 10, Jackson mountain. Red oxide of iron.

No. 11, Half jasper, half iron ore. Jackson mountain. Specular ore—somewhat micacious—compact.

No. 12, Found in a quarry at dock. Carbonate of lime and iron.

No. 13, Red oxide of iron, with specular ore.

None of the above specimens contain *phosphorus*, *arsenic* nor *sulphur*. The *gangue* is a mixture of *quartz* and of *alumina*, of *oxide of iron*, of *lime*, and of *alkalies*. No. 7 contains some silicate of iron.

ANALYSIS.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Gangue	17 00	28 50	41 00	12 50	14 50	4 —
Metallic iron	58 00	49 00	40 00	58 00	58 00	65 —
Lime	0 20	1 00	0 80	2 00	2 50	1 70
Oxygen and loss	24 80	21 50	18 20	27 50	25 00	29 30
	100 00	100 00	100 00	100 00	100 00	100 00

	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 13.
Gangue	6 00	8 50	28 00	44 50	44 50	25 50
Metallic iron	67 00	64 00	50 00	32 50	38 50	51 00
Lime	1 00	0 20	0 50	2 50	1 00	0 50
Oxygen and loss	26 00	27 30	21 50	20 50	16 00	23 00
	100 00	100 00	100 00	100 00	100 00	100 00

	No. 12.
Gangue	6 0
Alumina	0 5
Lime	30 0
Magnesia	5 8
Alkalies	0 8
Oxide of iron	5 2
Oxide of magnesia	1 8
Carbonic acid	31 5
Water	11 2
Soluble silicia	6 4
	100 0

No. 14. Nearly the same as No. 6.
4 50
67 00—Metallic iron.
Traces.
28 50—Oxygen and loss.

[Signed] L. E. RIVOT,
Professor of Analytical Chemistry and Director of the Assay Office.

LEHIGH IRON DISTRICT, PENN.

In the Lehigh district the stock of pig iron, which is nearly all No. 1, amounts to 34,150 tons. The contracts already made, for iron of this district for this year's delivery, approximate to 37,600 tons. There are seventeen furnaces now in blast, one to be put in blast by the middle of May, and one in July. The seventeen furnaces are producing weekly an average of 2,100 tons, making for the remaining thirty-seven and a half weeks of 1856, 78,750 tons, which, added to the present stock, gives an aggregate of 112,900 tons. In this estimate we omit the product of the two furnaces soon going into blast, to make up for the possible deficiencies that may result from accidents. If we allow for next year's market the production of four weeks in December, during which the product may be closed in by winter, we have 104,500 tons for the market for this year, less than already contracted, 37,600 tons; leaving unsold for this year's delivery, 66,900 tons. In these estimates no account is taken of the small sales in the district, nor of a few small shipments by railroad, made in 1856, prior to this date. The sales of iron in this district in 1855, approximated to 105,000 tons—equal to a reduction of stocks, of 19,000 tons. The stocks on the first of January last, approximated to 20,700 tons, and on the first of January, 1855, to 39,000 tons. The total production in this district in the year 1856, will approximate to 106,000 tons; assuming as a basis the data above given, which will prove reliable save as it may be affected by accidents in manufacturing, or by a change in the market. The production in the fourteen weeks past, has not averaged 2,100 tons; several furnaces having but recently been put in blast.

MANUFACTURE OF STEEL.

The manufacture of cheap steel is one of the most important problems for the metallurgist, and there is no doubt it would be much more extensively used if price were no obstacle. Several processes have been attempted in Germany, and for some years the make has been greatly on the increase. Tuyres, rails, &c., at the Exposition, attracted great attention, and as a proof that the indefatigable researches of the Germans did not stop there, we extract from the *Moniteur des Interets Materiels* a short description of the process employed by Capt. F. Uchatins of Vienna. The principal feature in the process is, that the inventor, in the first place, breaks the pigs into as small pieces as possible, then mixes them with metallic oxides and other ingredients, and exposes the whole to a strong heat to be melted, and thereby converted into steel. It will be seen that by this method the chemical reactions take place with greater facility than when the pigs are in larger pieces; and another advantage is, that the fusion takes less time and less fuel. The theory is, that the pig, in contact with the metallic oxides, loses part of its carbon, which evaporates as carbonic acid and oxide of carbon. If, before the process is completed, the operation is suspended, it will be remarked that the centre of the corpuscules is still pig iron; this is surrounded by a small zone of steel, covered on the exterior with a pellicle of iron. However, the inventor has discovered a practical means of producing steel, very good, and at a much cheaper rate, which is an important point. From experiments by M. Nozo, it appears that for almost every purpose the new steel is equal, or even superior, to that at present in use.

JOURNAL OF GOLD MINING OPERATIONS.

CALIFORNIA GOLD FIELDS.

Quartz Mining.—Intelligence from every quarter assures us that the past month has been one of progress in this important branch of California industry. The only new mill which has come under our notice the past month, is one in Santa Cruz County, which is being built by Imes & Co., the same company which is now operating with great success on the newly discovered ledges about six miles from Santa Cruz. They are putting up a new mill about four miles further down the Creek, where they will get a much better supply of water. They will put in twenty stamps. The rock in that vicinity still continues to pay remarkably well.

The Amador Sentinel says that there is a great want of water among the mills in that county, but that those which are able to run regularly are doing well. Several new mills are projected—no particulars given.

A rich quartz discovery has been made at Chinese Gulch, Calaveras County, by Messrs. Saunders, Wallace & Forbes. One ton of selected rock yielded 83 ounces.

The Sonora Herald says that Allen & Co., about fourteen miles above Sonora, are putting up an arrastre on their claims, which are known to be extraordinarily rich. Andrews, Cary & Co. have discovered a very rich ledge near Jamestown, from which they recently took out $500 in one day. Since the water has began to give out, many in different parts of the county are beginning to turn their attention to quartz.

The Marysville Herald of a late date says that a rich quartz lead has been discovered at Slate Creek by a Chilian, while on a hunting expedition. The Chilian was crawling under some bushes to get a shot at a quail, and discovered a lump of gold imbedded in quartz. He broke off a piece of the quartz weighing 25 pounds, from which he procured $200. Great excitement prevails in the vicinity, and a large number of claims have been staked off and registered. It has also been reported that the same lead has been discovered about five miles from Slate Creek, which promises rich results This ledge, we believe, is located in Sierra County, on the divide between Slate and Poor Man's Creek.

Placer Mining.—The season for surface diggings is about over. The gulches are nearly dry, and the water in the ditches is fast giving out. The low condition of the rivers, however, which are as low now as they usually are a month latter, will afford a fine season for those holding river claims. Extensive preparations have been made on all the principal streams for fluming, and the yield of gold from this source the present season will be unusually large. The same cause which is favorable to river mining will turn an increased attention to quartz mining.

OLD METHODS OF WASHING FOR GOLD IN NEW GRENADA.

A very able report has lately been issued by the New Grenada Mineral Land Company, which abounds in information relating to many portions of New Grenada. Among other interesting statements, is that which relates to the manner of washing for gold by the natives; it is as follows:

The ravines, runs, creeks, and rivers, and, indeed, every locality where gold could be collected from the "bowl-washings" of earth and sand, scraped together by a rude instrument, called the "almocáfre" (a Spanish word signifying gardener's hoe), have been washed over and over again. And yet, strange to say, these same localities, although the earth and sand has been

washed so many times, still continue to yield the precious metal. A native will select a spot in an auriferous stream, or the bed of a mountain torrent, as his own peculiar locality for washing; and he will have several of these, which are respected by his neighbors and associates. After every freshet or heavy rain, he returns to those localities, and washes the alluvial or the new deposits of sand brought by the water from the mountains or washed from the banks of the streams. He is always successful in obtaining more or less gold, and sometimes reaps largely. The old mines and excavations even are resorted to at intervals, and the detritus and rubbish washed for gold, oftentimes with great success.

The instrument used by the native gold-washer, named "almocáfre," is peculiar in its form and construction. The blade of the instrument has a semi-elliptical shape, is about nine inches long, and two inches broad at its base, with a gradual taper to the point, which is blunt. The shank, which is in a direct line with the long axis of the instrument, is cylindrical, and receives a short handle about eight inches in length.

With this implement, which is made of tough, well-tempered steel, the gold-seeker scrapes and digs among the boulders in the streams, and in the cracks and crevices of the strata every where.

The gold-seeker has another implement for testing the quality of the earth or sand to be washed. It is a boat-shaped piece of horn, named *cacho de catendor*. In this he collects a small quantity of the material to be tested, and by repeated jactitations with water, which is allowed to flow off afterwards slowly, the lighter and soluble portions escape, leaving behind the metal with its metalliferous associates.

When a locality is found sufficiently rich for washing operations, the loose earth, pebbles, and sand are scraped together, and if water is present, the larger pebbles and stones are carefully washed and thrown aside. The material thus collected is thrown into a wooden bowl (called by the natives, battea), and taken to a stream or pool of water, and there washed.

The battea or washing-bowl of this region, is peculiar also. It has a conical shape, and has two short projections from the brim about two inches long, and opposite to each other, which serve as handles. The cavity of the bowl terminates below in a point, but the outside is slightly truncated. The battea is made from the mountain cedar, and is light and strong.

This bowl, the native when washing, rotates, shakes, rocks about, and sways to and fro in a most dexterous manner, now raking with the fingers the pebbles from the top, and then stirring up the contents of the bowl with one hand, and with the other slightly rocking the battea so as to admit occasionally a slight dash of water over the brim. Next, a rapid movement, like the balance-wheel of a patent lever, and then a peculiar rocking motion which gently rolls the lighter particles over the brim, &c. Thus stirring, rocking and raking the contents of his battea, which gradually and beautifully lessen, the gold-washer finally rids the object of his eager search from the vexatious companionship of its more gross associates. Then comes a period of anxious expectation and of doubtful, trembling hope; but now, perhaps, the excited expectant suddenly ceases his operations, probably to strengthen his nerves, or to gather courage to meet the result of his labors, be they gratifying or otherwise: and during this interval or cessation of operations, he is likely to straighten his loins, to kiss his rosary, or to mutter an "Ave Maria." This done, he cautiously and deliberately commences to move his now precious battea with a slight oscillatory motion, allowing at times some limpid water to enter over the brim and trickle down the side. This waving to and fro over the surface of the sparkling sand still concealing in its midst the golden burden, bathes it and gently coaxes it to disclose to the quickly detective and scrutinizing eye of the covetous ravisher, the fascinating and world-sought thing to which so long it had been intimately and secretly united, and from which it yet requires all the patience and skill of the expert and rejoicing

captor to separate it. But with the invaluable and indispensable aid of water the ever-persecuting discloser of the secret hiding-places of the precious metals, the indefatigable gold-washer achieves the victory and secures his golden prize. This latter part of the operation requires the most delicate and dexterous manipulation, in separating the grains of sand and metalliferous particles from the pure gold. Indeed, now the management of the operation displays a high degree of art and dexterity, which can only be acquired by long-continued practice, and some consideration of the physical laws.

After continuing the swaying motion of the battea for a satisfactory length of time, the operator suddenly tips the bowl to one side, and allowing the water to escape, promptly checks the sand trailing after it at the very brim; then catching some clear water in one hand, and supporting the battea stationary with the other, he allows the water to trickle over the layer of particles nearest the brim, which carries off with its gentle current the lighter and worthless grains, but leaves behind the heavier precious metal. A dash of water is again admitted as the battea is "righted up," and then follows the slight swaying motion and a rapid shiver. Again the bowl is quickly tipped to one side with an accompanying "rigor," when the same process succeeds as before, to be repeated over and over again, after the previous steps have been duly performed. Thus does the gold-washer, taking every advantage of the greater specific gravity of the metal and the motive and dissolving properties of water, separate most effectually the gold, and purify it from all the gross and valueless substances associated with it, and almost without losing the minutest particles of the precious metal.

The workings of veins, since the Spanish rule, have almost been abandoned, being not as profitable as the gold-washings, because of the rude, tedious, and imperfect methods of extracting the ore and separating the metal. The Spanish mode of grinding the ore, by manual labor, between two small stones, which, under any circumstances, must have been a losing operation, was rendered almost an impossibility, on account of the matrix becoming so hard as to requre efficient implements to extract and pulverize it. For this reason, undoubtedly, all the excavations in veins have only penetrated a few feet blow the natural surface, and rarely ever into the compact portion of the matrix, although the Spaniards must have been convinced, from the explorations they did make, that the ore increased in richness as they descended into the vein.

The native of the present day is well satisfied with washings from an auriferous stream of a few ounces of wash-gold; and, with his characteristic apathy, never attempts to make an excavation in a newly-discovered vein, or in search of a deposit of "oro corrido," or wash-gold, excepting now and then a narrow tunnel, or "lead" into a hill, where he is oftentimes richly repaid for his labor. The tunnels, or guacas, as they are called, have been sources of great wealth to the gold-digger of this region, especially during the time of the Spaniards; and they constitute a large proportion of the excavations in this vicinity. The most unquestionable proofs still exist, of the abundance of wash-gold in the hills of Cocuyos, Guinea, Zapaterito, and Barrera.

In former times, the rivers of Santiago, Concepcion, Barrera, Zapaterito, San Antonio, and San Bartolomo were those most noted for their gold-washings; and they are the principal streams that yield the most satisfactory returns to the gold-washer of the present day. In these rivers there are many deep pools and eddies, where, from their depth, neither the Spaniard nor the native has been able to wash the auriferous beds at the bottom. One of these localities in particular is the lower falls of the San Jago, where, there is every reason to believe, an immense deposit now exists; for within the last two years exceedingly rich washings have been made from the earth taken at the margin of the pool below the falls.

To my own knowledge the washing of a single battea full of earth, has

given a pound weight of gold, and many successive bowl-washings have yielded each from one to three and four ounces of fine gold. At different times attempts have been made to wash the more shallow portions of this basin, but the depth of water has been too great with the rude methods adopted for the purpose.

Still, the existence of the great abundance of the precious metal was proven from the fact that a large amount of lump gold was obtained from a very small quantity of sand collected at these points.

The method of collecting the auriferous sand and detritus from the beds of the deep pools in the rivers and streams is by diving, and scraping it together with the almocáfre, and thus loading the battea, which they bring up from the bottom, and after carrying it to a convenient place, wash the contents. The contrivance of the native for the purpose of keeping himself at the bottom of the pool while engaged in collecting the detritus and sand from among the "boulders" and out of the crevices in the "formation," is very rude, but effective. It is as follows: He selects an oblong quadrangular stone of the requisite weight, say about ten to twelve pounds. One side of this he makes concave, to be adapted to the nape of the neck, and then about it he works a netting of "Bejuco," which is the natural rope of this country. To this netting he attaches a broad flexible band of tough bark by both of its ends, and of such a length as to be slipped readily over the head from behind forwards as far as the forehead, while the stone is resting upon the nape of the neck. With the stone thus arranged upon his neck, and armed with the almocáfre and battea, he cautiously wades to that depth where he can retain his foothold with his head above water; and then throwing himself forward into the water, the weight of the stone bears his head downward to the bottom of the pool. Here he secures the battea stationary by putting into it a stone, and then groping about, with almocáfre in hand, he scrapes together the auriferous sand and fills the battea. Before his battea is loaded, the diver is compelled, perhaps several times, to rise to the surface for fresh air; and this he does by slipping the band from his forehead and casting off the stone. After rising to the surface, he swims to the place where he can gain his foothold as before, and then drawing towards him the stone, by means of a cord attached to it, he replaces it upon his neck, and after he is sufficiently refreshed, dives in the same manner again. The battea is necessarily always retained where the depth of the water is not greater than the diver's height, as it would be impossible for him to raise otherwise the battea full of sand and detritus. By this rude and tedious management does the gold-washer obtain the gold from the bottoms of the pools, which have not, generally, a greater depth than his own height. In some instances, however, the beds of pools of considerable depth have been partly washed by some natives more daring and persevering than the rest, where the great abundance of gold has been an inducement. In these cases the diver only attempts to collect some lumps of gold from the crevices in the strata, and from among the loose rocks, or to gather a small quantity of auriferous sand in a "tortuma," or gourd, which is repeatedly emptied into the "battea" on the bank, and, when a sufficient quantity is collected, is there washed.

Old diggings, mines in veins, tunnels into the hills, and, in fact, every variety of excavation, are to be seen in great numbers in these regions, and particularly in this section. The extensive working in the mines of Véta Solida and Véta del Rey conclusively testify to exploration and mining on a large scale in former times, and with considerable intelligence and energy. As I before stated, since the time of the Spaniard there has not been much mining in veins; and for the last twenty-five years the gold-washings, also, have gradually declined, until at the present time, only one hundred pounds or so of wash-gold are obtained annually by the very few natives now engaged at gold-washing in this vicinity. However, some twenty-five years since, an enterprising New Granadian, Juan Lopez by name, worked somewhat extensively in the old mines and excavations of the Spaniards; but as far as known, he carried on his mining operations with no additional improvement upon the

old Spanish system, nor did he advance much further in his various explorations than the Spaniards originally. He worked principally in the "outcroppings" of the veins, and drove leads into several hills for deposits of wash-gold; yet in a few years' labor he amassed immense wealth, which he and his family succeeding him have managed to nearly dissipate in a few more years.

Since his time no one has worked here extensively, although many persons have acquired in a short time satisfactory competencies, and gone to live in other places to enjoy them. These persons have principally obtained their wealth from the deposits in hills and mounds, and from gold-washings.

Guacas, which are the so-called tunnels and excavations into the hills of this region, are very interesting objects for examination and scientific inquiry, on account of the novel geological conditions attending the presence of gold, which are exhibited by them. These guacas penetrate the hillsides at various elevations, differing greatly in their extent, and varying exceedingly in many instances from the horizontal direction.

There are, however, several circumstances, which, being apparently always the same, are found associated with these excavations without exception, and some of them are undoubtedly the indications which lead to the selection of the locality and govern the course and extent of the guaca.

At whatever elevation on the side of the hill the excavation may be, the opening is always at a considerable distance below the summit of the hill; and as the general direction of those tunnels is the horizontal, they penetrate the body of the hill at greater or less depths below the natural surface. The indication, which governs the selection of the spot for commencing a guaca, is the presence of a stratification called by the natives "pena," and a detritus, either superimposed or partially mingled with the upper portion of this strata, which yields gold. This deposit of auriferous detritus varies exceedingly in extent, but when it is confined to a few feet in breadth and thickness, it is styled a "venéro," or vein. The strata called pena is feldspar, or gneiss decomposed to a greater or less degree in its upper layers, which, colored by iron sulphurets, present the different shades of blue. As one descends in these strata, they become more compact and hard, and in no instance is gold found below the extent of decomposition and consequent dissolution in these strata. The vein or auriferous deposit is composed of "boulders" of trap, greenstone, gneiss, and feldspar; detritus of every description of rock belonging to this region and decayed vegetation, such as trunks of trees and fruits, some of which have lost entirely their vegetable matter, and are impregnated with aluminous earths; while iron pyrites, magnetic sand and crystallized quartz, and lastly, by far the most important ingredient, gold, in large quantities, fill the interstices. Above the auriferous deposit is superimposed a layer of porphyroidal clay, of no great thickness generally, which is variously colored by iron and its compounds. This layer is styled among the native miners here "sepé," and is not unfrequently absent or of very limited thickness. Above this layer comes a stratification, which from its position and character combined presents an interesting geological phenomenon worthy of especial attention. The name given to this latter by the native is "tosca," the signification of which I am unable to give. It seems to be of volcanic origin, having been evidently superimposed upon the "sepé" when in a molten state. It has many of the characteristics of lava, and would seem to have been the result of volcanic action while the surface of this region was submerged below the level of the sea.

This "tosca" is of varied thickness and extent, in some places reaching the surface, and frequently making a strata which extends throughout the body of the hill, overlaying the "sepé." In some guacas it forms the roof for their entire extent; and its presence is considered one of the most favorable indications of the existence of gold in the "venéro."

In most instances the "tosca" is covered by diluvium and alluvial earth, to a greater or less thickness, forming the summits of the hills. Now and

then, however, the "tosca" comes out to day on the plateaux of the guaca hills. This is the fact on the Cocuyos hill, one of the most celebrated of these eminences, where it may be seen and traced to considerable distances. The auriferous deposits in these guaca hills vary greatly in extent and disposition, as I have already remarked. Sometimes there is no distinct and uniform "venéro," but the deposit is distributed irregularly in layers of different thickness and limits, with interruptions like "faults" in a vein of quartz,—composed of the layers of peña and sepé, interposed in juxtaposition. This occurs generally when the deposit is located deep in the hill.

JOURNAL OF COPPER MINING OPERATIONS.

LAKE SUPERIOR REGION.—THE GREAT CONGLOMERATE LODE.

The following article we take from the Lake Superior Miner. Something on the same subject was published in the July number of this Magazine. If the speculations of the writer should be confirmed it will become a very important matter to the miners in the Lake Superior region.

It is clear that the interest of the Ontonagon district of the copper region is gradually centring upon that part of the mineral range which lies between the Flint Steel and the Ontonagon Rivers. The splendid results of the Minesota mine which have already been achieved, the sure promise of the National and Rockland, and the auspicious indications apparent at the new mines now commencing their works upon the common lode, all point to the bluff lying between the waters of those streams as the storehouse of incalculable quantities of metal, and the theatre of vast future mining operations.

The rock formations of this hill are divided longitudinally by several copper-bearing veins, extending for a great part of its length, three or more of which have been opened sufficiently to establish their character with considerable certainty. The most southern of these outcrops on the south side of the bluff, considerably below its crest, and holding its course with remarkable truth and regularity, is traceable for a distance of about 16,000 feet. The hill is broken down by a depression or gap at the eastern side of the Rockland location, but this does not materially affect the course of the vein. It differs from the other veins in the hill in two prominent particulars. 1st. Its dip or inclination is much nearer to the horizontal, being about 40° to 45° from vertical. 2d. It lies between the formations—the underlying rock being a belt of conglomerate, while the overhanging wall is trap.

These veins, at the surface, lie from 70 or 80 to 200 feet apart, and, in conformity with the whole system of the Ontonagon District, they dip to the north. Now, as the veins which lie to the north of the conglomerate are much more vertical, so to speak, it is clear that they will, in descending, meet with that lode, at various distances below the surface, provided all hold their present inclination to a sufficient depth. Among the valuable facts disclosed by the operations of the Minesota mine during the past twelve or fifteen months, one of the most interesting relates to the junction, below the surface, of the north vein and the conglomerate lode. It is found that the latter does not change its dip below the junction, but that the north vein falls into it, or rather branches upward from it, as the limbs of a tree lead off from the parent trunk which sustains them. It is also settled as far as the present openings can determine it, that the size and productive power of the lode is much greater below that point, as the trunk of a tree should be larger and stronger than the branches which it sends forth.

These facts, when observed in connection with its regularity of course, its great length on the surface, and its extreme richness, as disclosed by the openings in the Minesota and National mines, suggest, and, we believe, strongly support, the hypothesis, that the conglomerate vein of the Minesota Bluff, is the grand champion lode of the district, and that in its descent it will be found to cut off and carry all the veins in that hill.

It is not our intention at present to argue the question, whether it extends beyond the Flint Steel River, on the east, or beyond the Ontonagon on the west. But we wish to call attention to a few more of its leading features, as developed upon the locations where it is known to exist, and to glance rapidly at its prospective influence upon the copper production of this district.

It was upon the grounds of the National mine that attention was first seriously attracted to the importance of this great lode, though a shaft had previously been sunk upon it by the Minesota company near the present western boundary of their location. By following the conspicuous footsteps of the ancient miner the explorer was first led to its examination. The mould of many centuries had gathered upon the works of these mysterious men, and the removal of this was the first important step in disclosing the value of the great conglomerate lode. On clearing out a very deep pit or shaft which had become filled with sand, clay, vegetable matter, &c., the scaffolding used by the ancients was found, and a sheet or string of copper, almost continuous, was observed going down the side of the opening. Upon these indications they at once commenced work quite energetically, and for a time with very satisfactory results.

The existence of the same band of conglomerate upon the Minesota grounds was known to the agents of that mine. And as soon as the value of the lode lying upon it had been determined by the works of the National location, a cross cut was driven south from the north lode at the adit level of the former mine, which struck the conglomerate in a distance of about 96 feet, when vigorous operations were commenced at this point. An immense amount of copper has since been taken from the vein by this company. And though their works upon the north have shown very great richness of ground, yet, it is clear to us, that the sustaining power which has lifted the Minesota from an uncertain position to the highest rank among productive and paying mines, exhibiting the most magnificent results for the past, and giving the firmest assurances for the future—is the great conglomerate lode.

The Rockland is a comparatively new mine. Their vein and principal works lie on the north side of the Minesota Bluff. An adit is driven into the hill from the north, across the formation, through which the principal part of their stuff is taken from the mine. This was continued south after it had intersected their proper vein and the Minesota north lode, until a few months since, it cut the conglomerate. Works were at once commenced upon this lode by rising, and sinking a shaft, and by driving each way from the adit. Another shaft was also commenced further east. The openings at this place, thus far, sustain the general character of the lode as shown in the National and Minesota locations.

Openings have quite lately been commenced further east; two of which are upon the Flint Steel location. The indications, in all the new openings are of the very best character—the veins exhibiting great rectitude of course, and bearing copper.

As this great lode is now to be attacked along the whole length of line, as far as it is at present proved to exist, the indulgence of a few speculations as to its probable capacity for copper production may not be out of place. Its total length is about 16,000 to 17,000 feet, say 2,750 lineal fathoms. Now the vein on the Minesota location, at No. 3 shaft, has been opened for a depth of near 80 fathoms from the surface, and proves to be extremely rich in the bottom. The present workings certainly afford no reason for the apprehension that the deeper ground is likely to become poor. The reverse of this may be predicated upon them, particularly below the junction of the two lodes.

Though it is true that they have good ground every where, and some of their very rich workings are comparatively near the surface. If the lode is good to this depth throughout, there are near 220,000 fathoms of ground lying above the present bottom of the Minesota mine.

We have not the means of ascertaining *definitely* the value, per fathom, of the conglomerate lode at either the National or Minesota locations; nor yet of knowing what proportion is left standing as dead ground. The average yield of the ground broken in the latter mine for the last year was about 900 pounds rough copper per fathom. The riches of this ground, we believe, was in the south lode and in a counter leading from it. It would certainly be safe to say that it yielded 1000 pounds per fathom.

If one third of the vein is to be left standing as dead ground, and the constant yield is at the rate above named, then that part of the great lode which lies above the lowest works of the Minesota, will yield 73,300 tons of copper, worth at the present rates the enormous sum of $29,350,000.

But the present works upon it are mere scratches in the ground when compared with its great extent. Several European mines are worked at 2000 feet and more, vertical distance below the surface, though this enormous depth approaches that point where the finger of Deity admonishes man to go "no urther." Now such a vertical distance would make upon the present indication of the vein, about 466 fathoms depth, and would give in its whole length 1,281,500 fathoms of ground, which at the rate above named would yield 640,750 tons of copper, worth at present rates $256,300,000.

These figures, it will be borne in mind, relate to the conjectural product of a single vein, while upon the Minesota hill there are two others which have already been proved to be very rich. These will probably fall into the conglomerate lode in depth, but, for many years to come they will yield immense quantities of copper. And no account has been taken of the rich counterlodes, branches, and feeders, which, here and everywhere, form so important a part of the miner's wealth.

Should the present indications of this great mineral deposit be sustained, throughout its whole length, it is clear that, in a very few years, more copper will be taken from the mines of this hill than the whole peninsula at present yields.

CONNECTICUT MINE.

The Connecticut mine is now looking very well. Since last fall they have worked only six to eight miners, and with that small force they have raised and shipped in ten months some eighteen tons of copper. During that time they have sunk one shaft 60 feet deep,—sunk a winze 30 feet,—and drifted at various points to the extent of 130 feet,—showing that the openings have been kept along very fairly, for the force of work. They struck rich ground, several months ago, and its extent promises to be considerable. Shaft No. 1 is now sunk to the depth of 230 feet from the surface. The openings for about 170 feet down yielded stamp work, but a drift from that point disclosed several masses of a ton or more weight, and all the work below that depth has been in a strong lode from 3 to 4 feet in width, very uniform in size, and with walls very distinct and true. At one point, for a distance of 20 or 30 feet it was as much as 8 feet wide, carrying mass barrel and stamp copper.

We are pleased to learn that they are preparing to work an increased force during the coming winter. The present promise of their ground will certainly justify this, as the past ten months operations have been conducted so as to leave a profit.

MASS MINE.

At the Mass Mine they have lately uncovered a lode lying to the north of their main vein, which shows remarkably well for regularity, and which we regard as a new feature of great value to the location.

A correspondent writes from Houghton Co.:—"Mr. BALL has so far perfected his new stamping machinery at the Copper Falls Mine that he intends to commence on Monday the 1st of September the grand trial of its capability, according to his contract with the company. By that instrument he undertook to stamp and wash 1,500 tons of rock in 30 days, or 50 tons per day.

"Every mining agent should witness their operation during that time, and we assure all that do so will conclude that Mr. BALL is a genuine Yankee, and an inventor of no ordinary grade.

"It would not be judicious to express an opinion in regard to these stamps so near to the time of their trial; but it is obvious to the most careless observer that great ingenuity is exhibited in various parts of their construction. The rock is pulverized in a mortar or receiving cullender, of cast-iron, weighing 11 tons. The stamp head and post weigh 2,200 pounds, and by the pressure of steam is made to strike a blow many times the force of its own gravity. The machine rings a bell when the rock is required under the stamps for feed; and if the rock is not supplied in a given time, by reason of the carelessness of the tender, or from any other cause, the machine *stops itself*, and waits until it is properly filled.

"The washing apparatus is so neat in its operation that it might be seen in a parlor without soiling the room, and it seems more suited for a cotton factory than for the dirty work of washing copper. If these machines work, as there is every reason to hope they may, they will effect an entire revolution in the method of extracting the 'fine copper.'

"The new road to the Cliff Mine from Eagle River is so far constructed as to be now in use. Freight can be hauled over it at about one half the cost of transporting by the old road over the hill."

CLIFF MINE.

We learn that the Cliff Company have commenced the erection of new dwelling houses for their men, on the new road. The new buildings are of good size, and conveniently arranged, with a small plot of ground attached to each. It is contemplated to build a great many more next season, so that the old ones in use at present under the hill will be torn down. They have also offered to defray the principal part of the cost of a neat Protestant church, which will doubtless be built next summer. With all these improvements "Clifton" will be one of the most picturesque villages in the State.

In connection with this subject our correspondent most justly remarks:

"How pleasant it is to see taste and comfort consulted in the arrangement of our mining locations, or **villages**, as these locations must become where the mine is a productive one. We would like to see the agents, in laying out village or location lots, leave a reasonable garden plot to each house. Every family might have from 25 to 150 feet for garden and yard to make their homes attractive to themselves and others. We believe that stockholders by consulting the home comfort of their workmen, are consulting their own interest in the long run. Men who have spent long hours several hundred feet below the reach of sunshine must have recreation. And many who now become disorderly would not frequent the bar-room if they had a garden to cultivate or a comfortable house to bring themselves about.

"The Cliff is now using considerable coal as fuel for their engines. Our forests are rapidly vanishing away, and it will not be many years before the wood lots on many locations will be pretty well stripped. On this location Mr. Slawson clears up the land as fast as the timber is taken off, thus preparing it for agriculture, and making money for the company while it improves greatly the appearance of the settlement. There is no longer any excuse for bringing 'pressed hay' into the country."

ADVENTURE MINE.

The stamp mill of the Adventure Mine has been in operation for severa. weeks, and is now performing a clever duty. It has eight head of stamps, driven by water power. The arrangements for getting the stuff from the mine to the kiln, and thence to the mill, are very convenient. They have a well-laid tramway which reaches the mill on the creek in a few hundred feet from the burning-house. The preparation of the stamp work is also done by tribute—the tributer taking the rock from the mine, and receiving a certain rate per ton for the copper produced from it, when prepared for sending away. The stamp heads perform somewhat less than the usual duty by reason of insufficiency of power, but on the whole the mill can be operated in a small way with great economy, and the copper manufactured by it will be quite an important item in the production of this mine. Mr. Mason thinks it will make some four tons of copper per month; and this part of their product will probably yield a higher per cent. of ingot than their mass and barrel work, as a considerable portion of it is headings. If there is no extraordinary oss of time arising from breaking of machinery, this estimate will not prove excessive, as they can pulverize five or six tons of rock per day, and its yield of rough copper will be four or five per cent. So that it seems clear to us that their little mill, though a cheaply got up affair, will be of great value to the Adventure Mine.

The appearance of the Adventure is still very favorable, and important masses are now in sight in several parts of the mine. Their continued success in working on the tribute system is destined not only to have a great influence upon the value of their own location, but also upon adjacent grounds similarly situated. It is getting to be pretty evident that there is a "world of copper" in that hill, and we feel our confidence in its workable value strengthened by the results of each month's operations. Their production of copper for the present year will be quite an important contribution to the product of this district, but their operations are, in our mind, invested with an interest to which this alone would not entitle them. Their plans and sections show a labyrinth of veins and deposits, from which it is difficult to evolve any regularity or system, yet they manage to keep in sight of the copper all the while. On the southern side of their bluff they have a lode lying upon a belt of conglomerate upon which a shaft was sunk for a considerable depth. The vein is large, and its contents very soft—so that its cost for sinking was only about five dollars per foot—but it did not at that point show copper. In other general characteristics, however, it was very promising, and it is to be hoped that it will not be abandoned without further exploration.

TOLTEC MINE.

At the Toltec, they have lately met with a change of ground. The mine has hitherto been very dry, but lately they have struck courses of rock which are so seamed as to make a great deal of water in the mine. This would seem to indicate that the rock was softening. They have considerable copper in sight, but their ground has been very hard and expensive. Their works seem to show that the copper lies in two great courses, which dip to the east.

The machinery and surface improvements generally, are in fine order. The stamp mill, if pushed to its greatest duty, would pulverize almost half the rock of the district.—*Miner.*

CLEANSING ORES FOR SUBSEQUENT PICKING.

The following, which appears to possess merit, is an improvement recommended by a correspondent of the London Mining Journal:

I take this opportunity of making known a method of cleansing ore, when

coming from under-ground, for the purpose of picking. The system usually adopted is that of washing the ore upon a fixed iron grate, lying nearly horizontal in a stream of water, moving the ore to and fro by means of a hoe. This operation requires a great force of water, which, immediately it touches the ore, flows through the grate. To economize and make more effectual use of the water, I have employed a rectangular wooden trough, about 10 ft. in length and 1 ft. high, on each side lined, inside, with sheet-iron, to the height of 6 inches. The trough is more or less inclined, according to the quantity of water at command. The stream of water enters the trough at its higher end, and the ore is thrown in the centre of the trough. A triangular iron grate, formed as a hoe, and nearly fitting the angle of the trough, moves the stuff in such a manner that all the stones of a proper size for picking are caught and thrown over the higher end of the trough, on to the picking-table, whilst most of the smaller ones, and all the slime, run through the bars of the hoe to the lower end of the trough. The effect of the water in cleansing and separating the stuff is surprising, and the quantity of work done gives decided superiority to the system. The reasons are so evident, that I need add no further explanation, except that the system is nearly the reverse of that ordinarily employed, where the grate is horizontal, and a fixture; whilst in my plan, the basis, which is the rectangular trough, is a fixture, and the hoe, which serves as a grate and a common hoe at the same time, is nearly perpendicular, and movable.

In order that the cleansed stuff may be well spread before the picking hands, a contrivance, formed by cutting a rectangular board, about 8 ft. in length, diagonally, and joining the equal widths of each half at a right angle, is placed across the table, and extends to the trough; on this divider is laid a grate, through which any smaller stones which may have escaped the hoe fall. I introduced this very simple plan five or six months since, and can now recommend the arrangement for its speed, good effect, and economy.

NORTH GEORGIA MINING COMPANY.

This property, which is apparently a prolongation of the vein of the Hiwassee and other companies, is described in a report by Professor Julien Deby, from which we extract so much as may have a general interest. The property is known as No. 20 of 9th District and 2d section of Fannin County, Georgia:

This property is traversed by a copper lode, which is apparently the prolongation of the very prolific vein on which the Cherokee, the Hiwassee, the Cochego and the East Tennessee Companies have sunk shafts in the District of Ducktown. It enters the lot near its N. E. corner, and runs with a course about 20° E. of N. for some distance, after which it makes a curve, striking about 50° E. of N., and enters lot No. 53 (south of 20) not far from the third of the breadth of the lot from its S. E. corner.

A trench has been opened near to the southern extremity of the lode, near the dividing line between lots 20 and 53, and exhibits fine quartzose, porous *gossan*, containing imbedded fragments of hyoline quartz. The *gossan* shows here a thickness of no less than fifteen feet, and is walled on its S. E. side by talcose slate. The gossan is in some places somewhat compact, in others stalactical or botryoidal, and is separated from the talcose walling b a stratum of granular quartz, colored by oxide of iron. Not far from his trench, and N. E. from it, a shaft 77 feet deep has been sunk. This s aft traverses gossan of various qualities, some of it being quartzose and por us, other portions ochreous or sanguineous. The upper walling is formed of alcose slate, the lower walling of a hard, quartzose, micaceous rock, penetr ted by iron and copper pyrites and actynolite, and resembling in every res ct the same rock at the Congden mines. The *gossan*, at a few feet below he surface, is impregnated with green carbonate of copper, in beautiful gr en,

silky, fibrous masses, of various sizes. Specimens of the ore exposed to atmospheric influences soon acquire a coating of blue sulphate of copper, indicating th presence of a sulphuret even in the red gossan.

The lower portions of the gossan change their nature and aspect, and are of a black color, with numerous white specks of quartz and felspar intermixed. This is generally, although erroneously, known as the "black oxide;" it is an intimate mixture of black sulphuret of copper, iron pyrites, and black oxide of copper, besides small quantities of manganese and several other earthy minerals. Mixed with this black ore, are found considerable masses of apatite, and often pyritiferous albite with "copper smut," and occasionally smaller portions of crystalline, white carbonate of lime.

A short distance north of this shaft, a trench has been cut, uncovering the gossan, and not far north of this trench a second shaft has been sunk to a depth of near ninety feet. The strike is here 50 deg. E. of N. The vein is topped by talcose slate followed upwards by a schistoidal quartzo-micaceous-hornblendic rock, which becomes friable by exposure, and is itself covered by a stratum or lead of compact white quartz. From this shaft large quantities of the "black copper," with portions of gossany carbonate and silicate of copper have been extracted, besides yellow sulphuret, chalkopyrites and Phillipsite. At about one hundred yards from the east side of the lot, and north of the 2d shaft, a trench and a small shaft have been dug through a talcose-ferruginous-quartzose slate. All the distance from the 2d shaft to this 3d one, is strewn at the surface with fragments of gossan which are not distinctly observable further north.

At this point, or near to it, the lode seems to curve round, striking from 10 to 20 deg. E. of N., so as to run up to within a very short distance of the N. E. corner of the lot, not far from which a trench exhibits very fine gossan accompanied by a well-defined quartz lead. A considerable space intervenes between the 3d shaft and the indications in the N. E. corner, over which space no signs of a metalliferous lode are distinguishable, on account of the amount of superficial alluvium, so that possibly a second vein or a branch lode might exist there instead of a continuation of the main vein we have described. This is the opinion of several miners, but can only be determined with certainty by direct experiment. In other words, we have failed to make a complete geological connection between the southern portion with strike 50 deg. E. of N., and the northern portion with strike 10 to 20 deg. E. of N. The existence of only one vein, or of one vein with an intersecting branch, instead of two distinct veins, is a presumption of ours based on probabilities and analogies.

The dip of the copper lode on No. 20 varies from 80 deg. to nearly vertical. The ores will yield: the gossany carbonate with its gangue, about 5 to 7 per ct. of copper; the black ore about 12 to 20 per ct.; the yellow sulphuret about 40 to 50 per cent.; the chalkopyrites about 30 per ct. of copper.

The breadth of the vein, which varies from 10 to 15 ft., promises a most profitable mine. We believe that the main ore bed will be found to be the metalliferous quartz walling, and that the most profitable and abundant ore will eventually be the yellow sulphuret.

The linear extent of the vein through the lot, (nearly three quarters of a mile,) its considerable breadth, and the known fact that "never yet has a copper vein been known to 'give out' in depth," are most encouraging.

The exterior relations of this vein, its internal state, and the nature of its connections with the adjacent rock, are all of the most favorable kind, and we hesitate not in stating our candid opinion that this is a lot superior to the best in Fannin County, and inferior to none in Ducktown.

The trial works are now in a state which would allow the immediate starting of the regular working of the mine, and in the space of a very few days, ore of a *shipable* quality, and *shipable* quantities, could be extracted, under suitable management.

The mine we have attempted to describe above is not an "adventure,"

but a genuine and valuable copper mine. Its distance from the railroad, (about forty miles,) its well wooded surface, its good spring water, its healthy location, its vicinity to cultivated lands, are so many more items which warrant success to any enterprising miners.

QUARRIES AND CLAYS.

QUARRYING AND BLASTING ROCKS.

Among the numerous matters of importance which are just now exciting the attention of the mining community, there is probably not one carrying with it a higher amount of interest than the practice of blasting, whether in quarrying for stone or in obtaining metallic produce from mines. Since the first application of gunpowder to the riving and loosening of stone from the solid rock up to the present time, the operation may be considered as purely rudimentary; and as the price of this necessary has recently greatly increased, and is still increasing to a fearful extent, an important question arises as to the possibility of employing some other explosive element for this indispensable operation. Even should gunpowder be still the only available resource, a very important question arises as to the best means of economizing its power; and some very opportune information and remarks have just been made public by an excellent authority, Mr. William Sim, of the Granite Quarries, near Inverary. In the first place, the author shows that the ordinary method of blasting rocks involves three distinct operations—boring the holes, charging them with the explosive substance, and firing them. The first attempt made by progressive science to improve on the old system, at once tedious, uncertain, and unsafe, was several years ago, at the chalk cliffs at Dover, by the South-Eastern Railway Company, when 18,500 lbs., or 8¼ tons, of gunpowder, were fired with complete success in three mines simultaneously, by the aid of the galvanic battery. The next occasion in which electricity for firing the charge was brought into operation was at the Holyhead breakwater; and its introduction into Scotland was effected by Mr. Sim, at the Granite Quarries of the Duke of Argyle, as above-mentioned. By close observation, from practical experience, Mr. Sim has been enabled to divest the operation of much of the intricacy at first attendant on it at Dover, and the science is much simplified. The principal points to be considered are:—The best position in a quarry for a blast; the mode of forming and placing the mines; the formula for calculating the quantity of gunpowder, placing the gunpowder, electric wires, fuse, and tamping; with general results, estimate of costs, and the applicability of the system to various descriptions of rocks.

With respect to the best position for a large blast, that portion of rock should be selected the most homogeneous in its formation. As a general rule, 40 ft. may be considered the minimum, and 80 ft. as the maximum height of the mass to be displaced; and where the rock exceeds this, it should be apportioned, and brought down by a series of steps or lifts, when any mountain, whatever its height, may be brought down. The mines may consist of vertical shafts, sunk from the top of the quarry to any required depth, with horizontal headings branching off at bottom; or headings only may be employed, driven from the side of the rock. With shafts, Mr. Sim recommends that the powder-boxes be placed 50 ft. in from the quarry face, and 10 ft. from the natural dividing joints. Without shafts, an instance is given where the heading was driven 40 ft., then turned at right angles 12 ft., at the end of

which the powder-box was situated so as to be 40 ft. in thickness, with a burden 60 ft. high. The formula adopted for determining the quantity of powder required was, at the Dover cliffs, to have the charges in pounds of gunpowder, equal to one thirtieth of the cube of the line of least resistance; but it is now found better to cube the mass of rock to be displaced, ascertain the probable number of tons, and allow as a maximum charge 1 lb. of gunpowder to every 8 tons of rock. One instance is recorded where, in this proportion, 4,000 lbs. of gunpowder would have been required; but on account of the regular lie and form of the rock the quantity was reduced to one-half, or 2,000 lbs., and the operation was perfectly successful.

With regard to the expense of the most economical of Mr. Sim's processes, the cost of driving, wear and tear of tools, inserting the gunpowder, and stemming the mines, amounts to 24s. per lineal foot of mine, and the average cost of the mass of rock displaced is about 8d. per cubic yard, or 4d. per ton. It may be stated that the employment of electricity is only necessary when more than one box of gunpowder has to be fired; under other circumstances the safety-fuse is sufficient, being safe, economical and effective. The present exorbitant price of gunpowder will probably stimulate to the discovery of a more economical, and perhaps more powerful, blasting element. Already some new startling facts appear on the point of being brought to light, by which the electric spark, in its most condensed and attenuated form, may supersede other blasting compounds, and instead of being merely the agent to cause the explosion, become itself the blasting element, acting with resistless force, and at comparatively a merely nominal cost. An interesting paper on this subject appeared in the *Mining Journal* of 27th Oct. last.

THE SLATE MINES OF LEHIGH COUNTY.

A correspondent of the *Ledger*, writing from Slatington, Lehigh County, Pa., says: —

The mines which surround this town are situated near the base of the Blue or Kittatinny Mountain, about two miles south from the Lehigh Water Gap, embraced in 40 acres of land owned by the Company, through which the Trout Creek runs. Since the formation of the Company, the Directors have been in a condition to make improvements calculated to aid the miners and enhance in value the property; and in this they have been successful. Five mines are now opened, called the Washington, Trout Creek, Franklin, Bangor and Douglass. The Washington is the largest. From the base to the top, the height is 120 feet, and the front exposure nearly 300 feet. The Douglass is the smallest—that being about 60 feet high, with a front surface of about 75 feet. Out of this the excellent material for school slates is taken, on account of the softness and peculiar texture, and out of the other four the roofing slate is cut. A short distance north of this is a building in which a number of men and boys are engaged in scraping the slates for schools, with steel knives, similar in process to shaving shingles, while others are sawing pine boards into strips, by means of circular saws driven by an immense water power, and cutting in proper lengths, grooving, tenoning and putting the slates together and dressing the frames ready for packing and sending to market. This whole operation was interesting to the party, and when informed that over 300,000 feet of lumber were used in 1854 for slate frames, alone, those outside of the direction and officers were astonished. At present there are 131 hands employed about the mines, and 30 in the factory. Upwards of $2,300 are paid out weekly, besides about $500 per week out of the Company's store. The first year the mines were operated, 1848, but one load of slates was sent to market; and in 1852, 2,500 squares of roofing slates and 800 cases of school slates were sold. Last year the sales amounted to 6,000 squares of roofing and 1,600 cases of school slates; and so great is the demand, that with the limited accommodations for mining, 8,000 squares of roofing and 2,400 cases or about 250,000 school slates will be sent to market.

In a few weeks, a factory 150 feet long and 24 feet wide is to be erected, so as to afford facilities for the manufacture of one million school slates, and a force of cutters is to be employed large enough to get out 40,000 squares of roof slates per annum.

PLASTER BANKS OF SOUTH-WESTERN VIRGINIA.

These deposits, says the Abingdon *Virginian*, are to be found among the greatest sources of wealth and commerce to South-western Virginia. There is no portion of our broad continent, we presume, where it could be made more accessible, or where it is purer or more abundant. All that is wanting to bring it into market is a railroad, 15 miles long, from the Saltworks to the Cove, which would develop all this untold wealth without even the use of an engine. The plaster, being near the surface, can be raised without the use of machinery, and there is about 240 feet descent in the whole distance. With this regular and slightly inclined plane, the cars could be loaded at the banks and carry their treasure to the Saltworks without any propelling agent, and could be returned by mules, as was formerly the method pursued at the Mauch Chunk coal mines.

COLORING OF STONE.

Building stone may be tinted in different shades by impregnating it with metallic salts, and then adding a precipitating re-agent. By means of salts of lead and copper, with sulphuretted hydrogen, grays, browns, and blacks may be produced. Copper and ferrocyanide of potassium give a red tint. If porous limestones are boiled in solutions of metallic sulphates, carbonic acid is evolved, and the metallic oxide, combined with sulphate of lime, is deeply fixed in stone. In this manner, sulphate of iron gives rusty tints, sulphate of copper a fine green, sulphate of manganese a brown, and mixed sulphates of iron and copper a chocolate. The double sulphates thus formed increase the hardness of stone.—*London Artizan.*

MISCELLANIES.

ALUMINIUM AND SODIUM.

A correspondent of the *Transcript* whose initials are those of an eminent chemist of Boston, Dr. Charles T. Jackson, states some facts regarding this new metal which will interest our readers. This metal was first discovered in 1827 by Mohler, who procured it by the decomposition of chloride of aluminium by the action of potassium. He obtained it only in the form of fine metallic scales and globules, and it was alloyed with some platinum derived from the crucible in which the experiment was performed. Within the last two years Henri St. Clair Deville, of Paris, having invented a method of extracting sodium by a continuous process like that of the distillation of zinc, was enabled to decompose chloride of aluminium on a large scale so as to obtain the metal aluminium in considerable quantities, and he has extracted already between 50 and 60 pounds of this new and curious metal, and has demonstrated its valuable qualities.

At the present time M. Rousseau is the successor of Deville in this manufacture, and produces the aluminium, which he sells for $100 per pound or 100f. per kilogramme.

No one in the United States had undertaken the manufacture of aluminium

until it was made recently by Mons. Alfred Monnier, of Camden, New-Jersey, who has, according to the statement of Prof. James C. Booth in the Pennsylvania *Inquirer*, been successful in the manufacture of sodium by a continuous process so as to procure it in large bars, and of aluminium in considerable quantities, specimens of which he has exhibited at the Franklin Institute of Philadelphia.

M. Monnier is desirous of forming a company for the manufacture of aluminium, and is confident that by operating in a large way he can produce this metal at a much lower cost than has heretofore been realized. We would suggest the propriety of giving aid to this manufacture at the expense of the United States Government, for the introduction of new metal into the arts is a matter of national importance, and no one can yet realize the various and innumerable uses to which a new metal may be applied. It would be quite proper and constitutional for Congress to appropriate a sum of money to be expended under the direction of the Secretary of the Treasury, in the improvement of this branch of metallurgy, and in testing the value of the metal for coinage and for other public uses.

Aluminium is the lightest of the incorruptible metals, having only a specific gravity of 2.5—that is, twice and a half times heavier than its bulk of water. It is hard as silver coin, is richly sonorous when struck, and is not oxidated by the air. Its color is tin white. It is malleable and ductile, so that it may be rolled and hammered quite thin, or be drawn into fine wire. One pound of this metal will make five plates of the same size and thickness as would be produced from the same weight of silver.

It is admirably adapted for plate for table service, and the ladies will be quite pleased to have the cumbrous weight of a silver teapot banished from the table, and the lightness of aluminium substituted. For egg spoons, mustard spoons, &c., it is well adapted, since it is not stained by the sulphur which exists in eggs and mustard. It makes very light and pretty thimbles, and may be employed for numerous useful articles which are commonly made of silver. It has been proposed in France to make helmets and cuirasses for the imperial cavalry of this metal; but its present high cost prevents the realization of this project. According to the statement of Professor Booth, aluminium ought to be produced at a much lower cost than it is at present. Chloride of aluminium is made by mixing pure alumina with fine charcoal, and heating it red hot in an earthenware tube, and then dry chlorine gas is passed over the mixture, and chloride of aluminium distils over, and is condensed with sea salt as a double chloride of aluminium and sodium. This chloride is exposed to red hot vapor of sodium, and aluminium is reduced to its metallic state.

The raw articles then required for the manufacture of aluminium are: clay, sulphuric acid, soda, salt, manganese and charcoal—all common and cheap materials; and for the reduction of sodium: soda ash, carbonate of lime and charcoal. The cost of manufacturing the metal is then chiefly in the labor and apparatus, and the largeness of the manufacture may very soon diminish the cost per pound of the product. We would respectfully call the attention of Government to this subject, in the hope that M. Monnier may receive aid and encouragement in this manufacture.

MINING MAGAZINE.

EDITED BY

WILLIAM J. TENNEY.

CONTENTS OF NO. V. VOL. VII.

ARTICLES.

JOURNAL OF MINING LAWS AND REGULATIONS.

COMMERCIAL ASPECT OF THE MINING INTEREST.

COALS AND COLLIERIES.

IRON AND ZINC.

JOURNAL OF GOLD MINING OPERATIONS.

MISCELLANIES.

THE

MINING MAGAZINE:

DEVOTED TO

Mines, Mining Operations, Metallurgy, &c., &c.

VOL. VII.—NOVEMBER, 1856.—No. V.

Art. I.—GEOLOGICAL CLASSIFICATION OF THE MOUNTAINS OF A PART OF NORTH AMERICA—By Jules Marcou.*

An attempt to classify geologically, that is, according to their chronological order, the different chains of mountains in the United States, and the British Provinces, is an undertaking which in reality can be only preliminary, if we consider the small number of observations which have been made and the vast extent of country embraced in this portion of North America.

In Western Europe M. Elie de Beaumont has recognized and classified twenty-one systems of chains of mountains, and, in addition he has extended many of these systems to other parts of the world. Two of these extensions coincide in a most perfect manner with two systems of mountains which we find in a part of North America of which I shall speak presently. One designated as the *System of Ballon and the hills of Bocage*, and which has dislocated the beds of the coal series in Britain, the Westmoreland, the Vosges and the Hartz mountains, coincides exactly with the *system of the Alleghanies*, which has rendered to the United States the coal beds of the States of Pennsylvania, Maryland, Virginia, Kentucky, Tennessee, &c. The other, known under the name of the *system of Thuringia and Morvan*, and extended to North America, is found to coincide entirely with the *system of Keweenaw Point and Cape Blomidon.*

By following the method introduced and explained with so much talent by M. Elie de Beaumont in his late and remarkable work, entitled, "*Notice sur les systems de montagnes*," and by the aid of some excellent observations made by Messrs. Jackson & Hitchcock upon the directions of the ruptured rocks of New England, Nova Scotia, and Lake Superior, I am led to recognize thirteen chains of mountains in a part of North America. After deducting from this number the two systems that M. Elie de

* The Geological Chart of the United States by Mr. Marcou has attracted considerable attention in this country, and been received with various opinions of its merits. The above article is translated by us from a recent number of the Annales des Mines, where it appeared precisely as it is presented here, and upon the responsibility of Mr. Marcou. [Ed.

Beaumont has recognized heretofore by the extension of two of these systems of Western Europe, there remains eleven systems of mountains which I add to those known in this part of Geology.

Nevertheless, I repeat, that this classification is only preliminary, and I present it with all reserve, considering the small number, the difficulty and the insufficiency of the observations.

1. *System of mountains of St. Lawrence, (des montagnes Laurentines.)*

The granite, syenite and gneiss rocks which form the principal mass of the Lawrence mountains, upon the right bank of the river St. Lawrence, are affected by numerous dislocations which have elevated them in various ways. These dislocations are not all of the same epoch; however there is a principal course which is much more important than the others, and which is almost east and west with a small deviation of nearly 5 degrees; say for the system E. 5° N. and W. 5° S.

The dislocations are the oldest I have been able to find in North America. I regard them as anterior to the first beds of the lower silurian, that is to say, before the formation of the *Potsdam sandstone* containing the primordial fauna of M. Barroud.

As they are the oldest, it naturally follows that these primitive dislocations which form in reality the mass of the Lawrence mountains, have been subject to great alterations in consequence of the increase of the ranges of subsequent dislocations; and if we add to this, the great difficulty of exploring in a savage and desert country, we shall have an idea of the obstacles to their investigation. The localities in which the oldest system of dislocation may be observed the most advantageously are the north coast of Lake Superior, between Michipicoten and Pic; the north coast of Lake Huron, between the river Francis, the Lake Nipissing and the Fort Clarke; in short, the line which runs from Lake Simcoe in Upper Canada, a little north of the city of Kingston.

I regard as belonging to the same system of dislocation the centre of the group of mountains formed of eruptive and metamorphic rocks which constitute the high grounds of the States of Wisconsin and Michigan, between the Upper Mississippi and the Lakes Michigan and Superior. I say only the centre of that group, because I make an exception of all copper-bearing trap of the south shore of Lake Superior, which is of a much more recent age, as likewise the greater part of the locations which extend from the Wisconsin river to the river Menemonee. The greater part of the mountains of the north part of the State of New York between the Thousand Islands and Lake George are of the same epoch, as well as the two little granite groups in the State of Maine, between Moosehead Lake and the river St. John, and, in short, the mountains in the north of the province of New Brunswick, near Bathurst.

West of the Mississippi, between the Missouri, the Llano-Esta-

rado, the Rio Grande, and the Gulf of Mexico, we meet five masses of granite mountains, the course and age of which appear to coincide with the system of the *Laurentine* mountains. One of these masses is situated in the south part of the State of Missouri, another passes Little Rock, where it is traversed by the Arkansas river; a third, the most inconsiderable of all, is found 25 miles east of Fort Washita; the fourth forms an excellent landmark in the centre of the immense prairies of the country of the Commanche Indians, and is known under the name of the mountains of Witchita; in short, the fifth and last occupies the north of Texas, where it is traversed by the Colorado river between the rivers Llano and San Saba.

2. *System of the Two Mountains and the Montmorency.*

The dislocations which are the foundation of this system took place at the end of the deposits of the beds of the lower silurian system, that is, after the formation of the rocks of the group of Potsdam. Its direction, from the small number of observations I have been able to make, appears to be approximatively E. 40° N. to W. 40° S. The strata of the Potsdam group are very elevated near their junction with the eruptive rocks, and they are often metamorphic, a circumstance which has given them a hard quartzose aspect and composition. The localities where this system of dislocation can be best observed are, the environs of Quebec, particularly between the cataracts of Montmorency and Lorette; Mount Calvary, in the county of Two Mountains, near Montreal; and at Little Falls, in the State of New York.

I think we can regard as of the same age the dislocations which have taken place upon the north-west side of the mountains which are north of the State of New York and upon some points of the junction line of the silurian and metamorphic, which extends between the Wisconsin and Menemonee rivers in the east part of the State of Wisconsin.

The movement which has given birth to this system of dislocations has been much more inconsiderable than that of the St. Lawrence (Laurentine) mountains, and so likewise it is not perceptible over so great space; it has only modified some parts of the preceding elevation, enlarging it, and rendering it so as to form small adjacent chains to those of the more ancient mountains.

3. *System of Montreal.*

In many localities and especially at the cataract of Montmorency and at Little Falls, we find beds of the second group of the lower silurian, that I call *silurian moyen*, or group of Trenton, deposited horizontally upon the most inclined strata of the Potsdam, and being consequently an incongruous stratification. The beds of the group of Trenton have been likewise subjected to ruptures and dislocations immediately upon the termination of

their deposit. Without presenting either grand perturbations, or great upheavals, these dislocations, which have occurred at the end of the deposit of Trenton limestone, are nevertheless very clearly marked and have left very distinct traces, more particularly in Lower Canada. The summit of the mountain which overlooks the city of Montreal, is formed of veins of greenstone or trap, which have entirely crossed the strata of the Trenton group, and have sometimes flowed upon the silurian rocks. We meet many other of those veins of trap having exactly the same position upon the borders of the Ottawa river, as well as upon the mountains of Bel-oeil, Rougemont, Montonville and Johnson, near the rivers Richelieu, Huron and Yamaska. These latter veins appear to me to belong to the same system of dislocations as those of the mountain of Montreal, and their general direction is precisely from east to west.

I think that traces of this system will be found in other regions, and more particularly in Upper Canada and the States of New York and Maine.

4. *System of the mountains Notre-Dame.*

If under the preceding system the strata is very feebly broken and elevated, such is not the case with the system which I call the *system of the mountains Notre-Dame*, and which took place at the end of the deposit of the rocks forming the lower silurian. The beds which form the third group of the lower silurian, or that which I call after the upper portion of the (moyen) middle silurian, are composed of numerous strata of clay achist of a blackish color known in the State of New York under the name of the group of Utica and of the river Hudson. These strata, which form almost entirely the beds of the river Richelieu, of the river St. Lawrence below Montreal, and upon which is located Quebec, have been elevated all along that line even to Cape Rozier and the extremity of Gaspe.

The mountains Notre-Dame, formed of eruptive and metamorphic rocks, of which some peaks are 1,150 metres, owe their origin entirely to the movement of dislocation of which the mean direction from Gaspe appears to be E. 20° N. to West 20° S. I think many analogical accidents of the chains of mountains extending between Point Levi, near Quebec, even to Lake Champlain, owe their origin to that system of elevation; yet their directions are faintly manifest, owing to the enlargement of the chains with the system of dislocation which has immediately followed, and which has formed the Green Mountains of Vermont.

5. *System of the Green Mountains, or Meriden in New England.*

It is some time since Mr. Hitchcock has distinguished that system which he has designated under the name of the *Oldest meridional and Hoosac mountain system.* Being more developed

in the western part of the State of Massachusetts, it forms the Green Mountains of Vermont, and extends into Lower Canada even to the Chaudiere river. Its general direction is very near a meridian, with a slight deviation towards the east, which gives it an average of N. 7° E. and S. 7° W.

The dislocations which have caused this line of mountain chains took place before the appearance of the Alleghanies, and even immediately after the deposit of the upper silurian, as is proved by metamphoric fossiliferous rocks which Messrs. Jackson and Logan have found on the borders of Lake Memphremagog and St. Francis. Hence I regard them as being elevated and putting an end to the silurian period in America, before the deposit of the Devonian beds.

The igneous rocks which have made an eruption through the solid surface of the earth's crust, have most forcibly elevated all the sedimentary strata previously deposited; in addition, they have often reversed them, folded and distorted them and subjected them at the same time to most powerful metamorphic action, and which has been perceptible at great distances from the eruptive centres.

The system of the Green Mountains extends, as I have previously said, from the Chaudiere river in Lower Canada into the State of Vermont, which it forms entirely; it comprises, likewise, the county of Berkshire and the line of hills which extend between the Connecticut river and the city of Worcester in the State of Massachusetts; afterwards, it occupies the counties of Litchfield and Fairfield, in the State of Connecticut, and terminates in the neighborhood of Bridgeport on Long Island Sound.

Along the boundary line between the States of Connecticut and New York we see the crossings of this system with that of the Alleghanies; the latter, at a much later period, abutted against the dislocations of the Meriden system, which it penetrated in many places. The Geological Chart of the State of New York, published by its Legislature, shows most clearly the points of contact of the two systems.

The valley of the river Hudson from Saratoga to West Point, has been formed entirely by the system of the Green Mountains, and it is parallel to that range. The Green Mountains present at many places in Vermont, and more especially at the Chaudiere river in Lower Canada, veins of quartz containing native gold in considerable quantity.

The White Mountains of the State of New Hampshire owe probably a part of their elevation to this system. But the insufficiency and the difficulty of the observations in that country of wild and rough mountains does not permit me to venture any suggestions upon the age or ages of the chains which form the group of the White Mountains.

I regard as belonging to the system of the Green Mountains

the rupture and elevations which are found in Nova Scotia between Merigomish and Arisaig and Cape St. George.

6. *System of the Catskill Mountains.*

The end of the devonian period has been marked by ruptures and elevations of the strata of *old red sandstone* upon almost all the meridional line of New York State. The general disposition of the strata, particularly near the village of Catskill, gives for the direction of the upheaves E. 15° S. and W. 15° N.; a direction which coincides with the systems No. 3 and 6 that Mr. Hitchcock has indicated in the south-east part of Massachusetts. These systems of Mr. Hitchcock have dislocated the strata, which although very much altered by the metamorphism, can however be recognized as of the devonian epoch; they form the outline of the anthraxiferous basin of Bristol county. In New Brunswick we observe upon the outline of the coal series, different lines of dislocations, the direction of which falls into that of the Catskill Mountains.

Mr. J. W. Dawson, a geologist of Pictou, in a recent and remarkable book, entitled, *Acadian Geology*, derives from the end of the devonian period the Coluquid mountains, the mountains of Cape Porcupine in Nova Scotia, and almost all the hills in the south-east part of Cape Breton. According to this apt observer, the direction of the line of dislocation will be W. 10° S., which differs 25° from the direction of the Catskill Mountains.

7. *System of the Alleghany and Ozark Mountains.*

Geographers and Geologists have designated as Alleghanies or Appalachian chain all the mountains extending from Montgomery in the State of Alabama to Cape Roziere and Gaspe at the mouth of the St. Lawrence. According to the preceding classification almost all the mountains found in Massachusetts, Vermont, New York, Maine, and in Upper and Lower Canada, are much older than the appearance of the Alleghanies; and in addition, I have distinguished six systems of mountains of different ages and directions, and not having any connection with the age and direction of the Alleghanies. Thus I am led to consider the Alleghanies, in a geographical point of view, as commencing between Montgomery and Tuscaloosa, in Alabama, and extending without interruption to the left bank of the lower part of the Hudson river, in the county of Putnam, State of New York. And in a geological point of view the Alleghany system of dislocation is continued into the State of Connecticut to the east of New Haven; it traverses Rhode Island, which it forms almost entirely, thence enters the eastern part of Massachusetts, passing near the city of Lowell and terminating at Portsmouth in New Hampshire; afterwards it re-appears at Cape Sable in Nova Scotia and extends without interruption to Cape Canso

and the extremity of Cape Breton, and finally forms all the eastern and central portions of Newfoundland.

The general direction of the Alleghany system is north-east and south-west. We observe a deviation more to the east in a part of these mountains which extend around Harrisburg in Pennsylvania, and around the city of New York. These deviations arise from the encounter of the dislocations of this system with those of the Meriden system of New England, which in crossing and penetrating each other have resulted in a mixed direction, making an angle of 8 or 10 degrees more to the east, for the region of the Alleghanies which lies between the Susquehanna and Hudson rivers. The influence of this deviation is much more plainly perceived at the south-west, and I do not hesitate to ascribe to it considerable faults that are met with in following the foot of the high chains of the Alleghanies, in the western parts of Pennsylvania, Virginia and Tennessee, and which presents at times very angular curves in the form of a bayonet.

The precise epoch of the dislocation and elevation of the Alleghanian system is the end of the deposit of the carboniferous group, or coal series. To this system is almost entirely due the elevation of the States in the centre and west of the American Union.

The group known under the name of the Ozark mountains belongs to this system of dislocation of the Alleghanies; it took place about the end of the deposit of the coal series which it has elevated and dislocated in the same direction, north-east and south-west. Only there is an essential geological distinction to establish upon what is called the *Ozark mountains.* Geographers, and especially Major Long, who first made a scientific exploration in those regions, have comprised under the term Ozark, all the mountains which are found between the Mississippi, Kansas, the Prairies and the Red river. But we have seen above, that I refer to the St. Lawrence system many masses of granite mountains which are comprised in the limits indicated and which run E. 5° N. and W. 5° S. The carboniferous rocks repose horizontally at the foot of the masses which they surround, and consequently the dislocations which they have undergone in these regions are much later than the appearance of these islets of irruptive rocks. Besides, the direction of the ruptures and upheaval of the coal series are altogether different and coincide with those of the Alleghany system.

The chains of mountains forming the Ozark system, properly speaking, and excluding the granite masses of Fort Washita, Little Rock, and Potosi, are composed of parallel lines running north-east to south-west, with a slight deviation towards the north and having a breadth varying from 40 to 200 leagues. These chains proceed from the sources of the Little Sioux, in the north-

west of the State of Iowa; they traverse the Missouri and the Platte a little above the juncture of these two rivers and form the limit between the Prairie and the wooded country. In Arkansas we see them most developed in the county of Washington near the Ozark villages, and Van Buren and Shawnee; Mount Delaware, near Fort Arbuckle, is likewise a portion. In short, this system, which is traversed by the Red river near Preston, proceeds into the northern part of Texas, where it forms the line of hills upon the Brazos, Trinity and Colorado rivers.

The group of Ozark mountains is not pierced in any part by eruptive rocks. It should be considered as a second fold of the Alleghanies, which is effectually parallel to the first and at a distance of 500 leagues. The elevation of these mountains is nowhere very considerable; it varies between 200 and 1000 feet above the level of the surrounding plains.

8. *System of Point Keweenaw and Cape Blomidon.*

The triasic rocks, or more correctly the *new red sandstone*, in point of geographical extension in the United States, act a most important part, for they alone cover a third of that immense country, and added to the carboniferous rocks, they form two-thirds, leaving only a third of the surface of this portion of the continent to the eruptive rocks, and to the other periods of the sedimentary series. The strata of the trias has been subject to two special dislocations, which have taken place, the one towards the middle of the deposit and the other at the end. The last is far the most important; nevertheless the first, elevating the strata of the *new red sandstone*, has made itself perceptible at very wide distances, and with an intensity which, though inconsiderable, has however produced very important chains of mountains, especially at Lake Superior and the Bay of Fundy.

After having made many observations upon the direction presented by the first location, I arrived at an average direction of E. 35° N. to W. 35° S. In many localities and more especially in the valleys of the Connecticut and New Jersey, we meet with numerous threads of trap belonging to this system, and of which the direction is more to the north, and sometimes confounding themselves with the system of the Alleghanies or even with that of the Green Mountains; in consequence evidently of the crossings which have changed the primitive direction of these threads. In order to obtain the normal direction of this system it was necessary to study it at Point Keweenaw, Isle Royale, Cape Thunder, on Lake Superior, or as well upon the two parallel coasts of the Bay of Fundy, at the Capes Split and Blomidon, also at the islands of Madaline in the Gulf of St. Lawrence. These ruptures of the beds of lower trias envelope enormous threads of basaltic trap, which have made an eruption and are spread in streams covering the sedementary strata. We find in this trap some veins

of native copper which traverse the threads perpendicularly. Besides, we frequently find there all the ores of copper, native silver, and many zeolitic minerals.

The understanding and importance of the system of Point Keweenaw and of Cape Blomidon is entirely due to Dr. Chas. T. Jackson, a celebrated geologist of Boston, and known especially in the scientific world for his discovery of ether. Many American geologists have in vain attempted to refer this system of dislocation to the more ancient systems, going so far even as to connect it with the system of Laurentine mountains. After having investigated the question with the greatest care, and in many places, I an entirely of the opinion of Dr. Jackson.

According to the description of Sir R. H. Bonnycastle and Mr. Logan, I refer to this system many threads of basaltic trap, and strata of red sandstone, which are found at Cape St. George, Newfoundland, in the Bay of Chaleurs, between the river Ristigouche, Richmond, and Port Daniel. Besides, from the information which I have received respecting a portion of the mountains surrounding Fort Webster, in the Sierra Madre of New Mexico, I think that the threads of copper-bearing trap which have there been worked, at a place called Santa Rita del Cabre, belong to the system of Point Keweenaw and Cape Blomidon.

9. *System of the Sierra Mogoyon, or Blanca.*

In one of the most central and unexplored parts of North America, we find a system of mountain chains called by trappers and hunters, Sierra Mogoyon, or Sierra Blanca, which extends between the Sierre Madre, the river Colorado-Chiquito, the *Bill* Williams' Fork, the Grand Colorado river of California, and the Gila river, or in other words, between 35° and 33° of latitude, and 108° and 114° of longitude, west of Greenwich. This system is composed of a great number of chains and parallel ridges, of which the general direction is N. 60° W. to S. 60° E. The highest points of these mountains are near the sources of the Gila and Prieto rivers, where they appear to be 3,000 to 3,500 metres above the level of the sea.

From the small number of observations which I have been able to make in a rapid geological reconnoissance of that region, I think that these chains of mountains belong to a system of dislocations, which has ruptured and elevated the strata of the upper trias, and which has ended the triasic period of the new red sandstone of North America.

The rocks which the Sierra Mogoyon has brought to the surface are as follows:—a highly amphibolic granite forming the centre, then metamorphic quartzose rocks covered by strata of *old red sandstone* or devonian; these strata are formed of beds of very hard red sandstone, resembling the sandstone of Catskill in New York State. Above we find the *mountain limestone* highly

developed, and containing numerous characteristic fossils of that series, then the sandstone of the coal series, the *magnesian limestone*, and, finally, numerous strata of trias. The jurassic series is deposited horizontally upon slightly elevated strata of trias, and in a disordered stratification, such as I have observed at Fort Defiance and the Chevalon Fork.

I think that the dislocations which have affected the upper trias, containing the coal near Richmond, in Virginia, belong to this system, as also the mountain chains which extend between the Great Salt Lake and the Serpent river, or Lewis' Fork of the Columbia.

The Shasta range, forming the boundary between California and Oregon, and which occupies all the country comprised between the Sacramento and Willimette rivers and capes Mendocino and Umpqua, has a direction which coincides precisely with the system of the Sierra Mogoyon.

10. *The system of the Rocky Mountains and of the Sierra Madre.*

The Rocky Mountains and the Sierra Madre form, in the centre of the American continent, a kind of convexities (bombements) following parallel lines, in some degree symmetrical. Often these convexities are broken by long narrow lines, and then the eruptive rocks have forced themselves a passage, elevating and dislocating forcibly the sedimentary rocks belonging to the carboniferous, triasic, and jurassic series.

The general direction of these chains is on an average N. 15° W. and S. 15° E., and the age of upheaval is the end of the jurassic period and before the deposit of the *néocomien* series of America. The carboniferous strata, and above all, that of the *mountain limestone*, are forcibly broken and elevated, for they are found in contact with the eruptive and metamorphic rocks; and I have encountered the *mountain limestone* with its most characteristic fossils, even at an elevation of 4,000 metres above the level of the sea.

Having ascended one of the highest peaks of the Rocky Mountains which we found in the vicinity of Santa Fé, in New Mexico, the elevation of which is 4,500 metres,—from that height, favored by the pure and light atmosphere peculiar to that region, I discovered a horizon having a radius of 60 leagues, and which embraces many chains of the Rocky Mountains, such as the Sierras Manzana, Sandia, Jesuez, Taos, San Juan, a part of the Sierra Madre, groups of old and extinct volcanoes, and two Sierras which run at the side of the river Peco. I have never seen, even from the summit of the Alps, the lines of dislocation so determined, and the parallelism of the lines so visible, with the most neat and marked curves.

The ridges (écaillements) and convexities forming this system of the two groups of the Rocky Mountains and of the Sierra

Madre, occupy a breadth which varies from 50 to 70 leagues; the eruptive rocks do not appear at each of the ruptures, and do not exceed in others a breadth of 4 or 5 leagues, often even the granites and sienites appear only on a space of half a league, in a very extended section of the chain perpendicular to its direction.

As in all the great mountain chains, so in the Rocky Mountains there are lines and accidents of dislocation anterior and posterior to the principal upheaval. Thus the Placeres mountains south of Santa Fe, and the mountains east of San Pedro, have a direction and accidents of stratification which indicate a date anterior to the appearance of the Sierra Sardia which is at the side.

The insufficiency of my observations upon these vast regions of the Rocky Mountains and the Sierra Madre obliges me to confine myself to these summary indications of a portion of the dislocations which are found there. Being the first pioneer of Geology in these desert countries, I have fixed only a single landmark.

11. *System of the Coast Range of California.*

The entire length of the coast of the Pacific Ocean, extending from Cape St. Lucas, in Lower California, to Cape Mendocin, in the county of Humboldt, in Upper California, we observe lines of mountains of small elevation, being in general 150 to 400 metres above the level of the sea, and which are known under the same of the Coast Range of California. The direction of this system of mountains is not far from N. N. W. and S. S. E.

The part of the coast where this system is the most distinct and easy for observation, is from the Pueblo of Los Angelos to the Bay of Humboldt, and between the sea and the rivers San Joaquin and Sacramento. In the small number of rapid observations which I have been able to make, around los Angelos, Santa Barbara, Monterey, Santa Clara, San Francisco, and Contra Costa, it appeared to me that the dislocations and ruptures have taken place at the end of the eocene tertiary epoch, as appears to be indicated by the beds of limestone and sand containing fossils characteristic of the eocene, and which are found especially south of Monterey and Monte Diablo in the county of Contra Costa.

The celebrated Golden Gate, or Port of Gold, of the Bay of San Francisco, traverses this system. The rocks which compose it are especially of a metamorphic and eruptive origin, and they contain rich mines of quicksilver, silver, copper, and iron; but thus far no gold has been found there.

Most of the chains of the Coast Range are crossed and penetrated by dislocations which have followed immediately after, and which have given birth to the system of the Sierra Nevada. These crossings are seen particularly near the mission of San Fernando and the Tajon Pass, and also near the sources of the river Russe in the county of Mendocino.

According to a manuscript chart and verbal communications made to me in 1854, by the celebrated and unfortunate Count Gaston de Raousset Boulbon, I refer to this system of the Coast Range, the mountains of Sonora, comprised in the country of the Propayos Indians, and the Sierra of Arrisona. There, as in California, we do not find gold, but many very rich mines of silver, copper, lead, and quicksilver; it was in attempting to endow France with this new Peru, that Raousset has obtained the celebrity of a new Cortez, dying at the climax of his adventurous career.

12. *System of the Sierra Nevada.*

We comprise in this system not only the chain of the Sierra Nevada, known among geographers as forming the eastern limit of California, but likewise a group of eight or ten other parallel chains, and which extend to the east, even to the further side of the river Colorado. In a word, the group of mountains forming this system comprises all the great American desert which extends from near the Salt Lake and settlements of the Mormons to the plains of the Sacramento and San Bardino, running north and south for ten degrees of latitude.

The lines of dislocation run north and south, giving thus a second meridian system in North America. As the rocks which compose all these chains are principally crystalline, eruptive, and metamorphic, and as they contain likewise veins of auriferous quartz, directed likewise from north to south, and of the same epoch as the appearance of the other rocks of this system—we see that there seems to exist a relation between the deposit of gold and the meridian direction of the chains of mountains, especially if we recall to mind that the three systems of mountains where gold is most common are the meridian systems of the Ural, the Sierra Nevada and the Australian Cordilleras.

The sedimentary rocks are very rare in the mountains of this group. There are especially pudding-stone, white and red sandstone badly stratified, and white sandstone. Fossils being very rare in the elevated and often highly inclined strata, it is difficult to assign a precise epoch for the relative age of the Sierra Nevada. That which is certain in my mind, is that this system is later than the eocene period, and yet earlier than the quaternary epoch. It may be at the end of the miocene, or after the pliocene. In this respect I agree with Sir Roderick I. Murchison, who considers, in his late and excellent work, entitled *Siluria*, the deposits of auriferous sands of the Ural and of Australia, as effected at the epoch of the quaternian drift, which gives as the geological age of the veins of auriferous quartz, the end of the tertiary epoch, or rather the end of the miocene period.

The Sierra of Batueo and the mountains which limit the basins of the rivers San Miguel, Sonora, San Jose, Cruz, in the State of Sonora, belong to the system of the Sierra Nevada. Their

direction is likewise north and south, and they contain in their bosom, veins of auriferous quartz identical with those of California.

13. *System of the Sierra of San Francisco, and of Mount Taylor.*

We have, in about 35° of Latitude, from Soda Lake, which terminates the River Mokaine, near the Colorado of California, to the sources of the Arkansas and Caanadive rivers, a volcanic belt running from west to east, and consisting of immense extinct volcanoes, the two principal ones of which bear the names of the Mountain of San Francisco and Mount Taylor.

The height of many of these volcanoes is considerable; thus the principal cone of the Sierra of San Francisco is 5,000 metres, and Mount Taylor surpasses 3,500 metres. All these volcanoes, the slides and secondary cones of which occupy a great surface, are actually extinct and do not appear to have been active for many ages.

The current of lava covers in many places, particularly in the valley of the Rio Grande, the drift of the quaternary epoch, and also the alluvium. A fact which seems to indicate the relative age of this volcanic band to be the end of the quaternary period.

More to the north, and following one of the lines of dislocation of the Sierra Nevada, we find, running north and south, on the meridian of 122° west of Greenwich, a volcanic line, in which most of the volcanoes are still in a state of activity, without interruption, especially at Mount St. Helena, near the Columbia river in Oregon, and Mount Baker in Washington Territory. The age of this last volcanic line appears to be the same as that of the line of extinct volcanoes above-mentioned, so that we have a rectangular volcanic system, the two directions cutting at right angles, and yet both of the same geological age. This system does not appear to me to encounter that noticed by Elie de Beaumont as composed of three volcanic bands, forming a single triangular system.

I have not yet found, with certainty, the system of dislocation which took place at the end of the cretaceous period, and I am greatly disposed to adopt the opinion of Elie de Beaumont, who for a long time has noticed in the Alleghanies, ruptures which should belong to this period. Those dislocations are found principally in North Carolina and Georgia.

In closing this hasty and imperfect attempt at a classification of the mountains of a part of North America, I express to geologists the relations which exist between the different periods or groups of American series, and the lines of dislocation and the elevations which traverse this great country. There, as in Europe, the chains of mountains have intimate relations with each division of the chronological scale of stratified series.

ART. II.—THE IRON MANUFACTURE OF GREAT BRITAIN—THEORETICALLY AND PRACTICALLY CONSIDERED. By WM. TRURAN, C. E. No. 9.

SEC. XI.—UTILIZATION OF THE GASES FROM BLAST FURNACES.

THE economical application of the combustible gases emitted from blast furnaces has been attempted at several works in this country with varied degrees of success.* They have been collected, and their combustion effected under the boilers of the blowing engines; but in only one instance have we observed the engine working from the heat given out by the gases alone. A quantity of coal, in many instances quite sufficient of itself if properly applied, is consumed, in addition to the gases, in order to obtain a sufficiency of blowing power.

They have also been applied to heating hot blast stoves, and with partial success, though the heat maintained is much inferior to that with coal fires. For this purpose, however, they may be used more advantageously than under the boilers. The heat maintained is sufficient for the blast, but is usually much lower than is required for the rapid generation of steam.

From M. Bunsen's analysis of the gases escaping from the Alfreton furnace, it appears that they are capable of yielding nearly 82 per cent. of the heat evolved during the combustion of the fuel. The consumption of coal in the 24 hours was equal to 18 tons 17 cwt. Hence, at this percentage, the gases are capable of yielding caloric equal to that produced by the combustion of 11 tons 7 cwt. of coal. If we allow 7 lbs. per hour per horse power, as a fair estimate, the combustion of the gases should generate caloric sufficient for maintaining in motion an engine of

* The first attempt in this country to utilize blast furnace gases by effecting their combustion appears to have been made by the Ebbw Vale company; the partial success attending their experiments induced other iron masters to test the commercial value of their furnace gases. In Mr. Blackwell's paper on the Iron-making resources of the United Kingdom, it is stated that they were first applied at the Ystalyfera works; this is an error, the more inexplicable that neither in the patent, nor in the report of its workings, read at the Swansea meeting of the British Association, do the proprietors make any mention of the combustion of the gases, but state it to be an invention for using the waste heat of the blast furnace. At a subsequent meeting of the Association, after their combustion had been successfully effected at the Ebbw Vale works, it was stated that an improvement had been made in the mode of applying the gases at Ystalyfera—effecting their combustion with atmospheric air.

Mr. Blackwell is also incorrect in stating, that the application of gases was made in the United States successfully long before it was attempted in this country. For several years previously, at several American furnaces the blast was heated, and the steam generated, by the heat given off at the tunnel head, but the application of gases, by which must be understood their combustion with atmospheric air, was made nearly at the same date in both countries.

151 horse power. The power absorbed in compressing the air, after ample allowance for friction and waste, did not exceed 40 horse; consequently, in this furnace the gases were capable of generating nearly four times the power required for the compression of the blast.

According to M. Bunsen, the temperature ordinarily attainable by the combustion of the gases is 3083°; but if hot air is employed this may be increased to 3632°. Cast iron melts at 2192°; consequently, the temperature capable of being attained is amply sufficient to melt and work the iron in the advanced processes.

But the power realized when the combustion of the gases has been effected under the most favorable circumstances, falls far short of the above. The calculations of the chemist on this subject, and the results obtained in practice are widely different. The power actually obtained is not usually so much as 20 per cent. of the theoretical quantity; while the temperature produced by their combustion is probably under one third of that given by M. Bunsen. Certain it is, that in no instance in this country has a sufficient temperature been permanently obtained for the melting of iron, or for any operation demanding a higher temperature.

The cause of this great discrepancy between the theoretical estimates of the analytical chemist, and the results obtained in practice, we attribute to the generally limited acquaintance possessed by chemists of blast furnace operations, and to the impossibility of obtaining, under the most favorable circumstances, more than a moiety of the heat.

We readily admit that the gases escaping from certain blast furnaces may, with proper management, be made to yield 82 per cent. of the caloric evolved during the imperfect combustion of the fuel; but we dissent from the generally received opinion, that a sufficiently intense heat can be maintained by their combustion for the purposes of the forge, or for the rapid generation of steam. We are aware that on the continent of Europe, the gases have been applied experimentally to the melting of iron, but the value of their application in the large way has yet to be ascertained. That they have not thus been applied, notwithstanding the length of time which has elapsed since the first experiments, and the generally favorable opinion entertained of their value, appears unaccountable to theoretical writers, and is not unfrequently quoted as evidence of the backwardness of the manufacture in this country, and the disinclination of iron masters to adopt ascertained improvements.

The caloric is produced by the combustion of the carbonic oxide and hydrogen. The proportion which they bear to the entire column is 36 per cent. Nitrogen and carbonic acid which yield no heat are present to the extent of 63 per cent.

If the combustible gases, carbonic oxide and hydrogen, are of

themselves capable of generating a temperature of 3083°, the presence of nitrogen and carbonic acid reduces it in the same ratio as they exist in the column. A certain number of units of heat are generated by the combustion, but instead of being concentrated they are disseminated through a volume of other nonproductive gases, and in consequence of this diffusion the temperature attained is inferior to that necessary for the manipulations of the forge. The quantity of caloric generated remains unaltered, but the temperature attainable decreases from 3083 to 1100°. But the admission of atmospheric air to effect their combustion augments the volume, thereby reducing the temperature of the ignited gases to a still lower point; in practice the working heat cannot be estimated at more than 800°.

This would be amply sufficient for generating steam and for heating the blast, but, owing to the dissemination of the units of heat through such a large volume of gas, the quantity in contact with the plate iron is small, and the vaporization of the water is conducted on a much slower scale than with coal fires. At the Dowlais works, three several experimental trials of the gases were made, but the temperature attained rarely went above a dull read heat, and the evaporative power of the boiler, as compared with its performance over a coal fire, was reduced nearly two-thirds.

At the Aberdare furnaces the gases are brought down and applied to the heating of 5 boilers, but as there are 6 boilers with coal fires, the insufficiency of the gas alone is very apparent. Prior to its application 6 boilers with coal fires sufficed to generate steam for two engines; now there are 11 boilers for 3 engines. The consumption of coal under the coal-fired boilers is about 14 tons a day, or 5 cwt. per ton of pig iron made by the furnaces. Now, as 6 cwt. is a large allowance for ordinary engines, the saving of fuel at these works, through the utilization of the gases, must be very inconsiderable.

In other iron-making districts, the gases have been applied to the engine boilers and hot blast stoves, effecting a saving in every case, and diminishing the consumption of coal formerly considered necessary for generating and heating the blast.

It is not enough, however, that there be a saving, if that saving is insufficient to compensate for the greater outlay of applying the principle of heating with gas. From the inferior heating power, a large number of boilers are required. At the Ebbw Vale, Aberyschan, Sirhowy, Aberdare, Ystalyfera, and other works using the gas, the number of boilers now in use is nearly twice the number which formerly sufficed with coal fires only. The necessity of having a larger number of boilers, shows in the most conclusive manner, that the available heating power of the gases is greatly below the theoretical calculations of the chemist. If it was equal, or superior, the boiler surface formerly employed, would have been amply sufficient.

Much of the inferior evaporative power of boilers heated by the gas is owing to the incrustation formed on the exterior of the plates. On the coal-fire boilers a thin covering of carbonaceous matter is deposited, which, to a certain extent, interferes with the rapid communication of caloric, but with the gas the defective communication is greatly increased. After the lapse of a few days the incrustation increases at places to a depth of several inches, and materially interferes with the generation of the steam. In such cases it is necessary to frequently clean the surface of the boiler.

There are circumstances, however, in connection with the withdrawal of the gases, which require from us a brief notice. Although they do not hesitate to state, that the gases may be withdrawn without disturbing the smelting operations, chemists are not agreed respecting the level at which this may be done. From this difference of opinion we infer, that their withdrawal can be effected at a certain point only, the position of which remains to be discovered.

In the charcoal furnaces it appears that the gases, to be of value for combustion, must be withdrawn from a low level, probably at or near the boshes, where they are rich in carbonic oxide; but their entire withdrawal at this low level disturbs the operations, by depriving the superincumbent materials of the gaseous carbon and caloric. Hence, in these furnaces, only a portion of the ascending column can be withdrawn. It is conceded by chemists, that the entire withdrawal of the gas ascending in these furnaces would seriously disturb the operations. Now, we cannot see the value of inquiries on furnace gases which merely result in statements, that a portion may be withdrawn at some part of the furnace, but leaves undecided the quantity or proportion, and exact position for withdrawal; nor do we believe, in the absence of all evidence on the subject, that, while the withdrawal of the whole column disturbs the operations, a portion can be withdrawn without causing any disturbance. For, if the loss of the carbon and caloric of the entire column is injurious to the operations, the loss of a portion, however small, must be felt, though in a less degree.

The gas escaping from charcoal furnaces contains a minimum percentage of the combustible gases, and at the top their low heating value does not warrant their collection. In the best regulated, the carbonic oxide does not exceed 4 or 5 per cent., while the carbonic acid forms 30 to 36 of the entire column at the level of escape. In the coal and coke furnaces of this country, the percentage of carbonic oxide rises so high as 42, while the carbonic acid nearly disappears. The reason of this greater richness in carbon is entirely due to the large consumption of carbon near the level of escape, of which we shall speak more fully in section 13. Containing, however, so large a percentage of car-

bonic oxide, with a minimum quantity of carbonic acid at the surface of the materials, their withdrawal from the furnaces of this country is generally effected at this level.

Various modes of collecting the gases have been tried; the one which appears to answer best we have delineated in connection with the cupola furnace at the Sirhowy works, plate 4. A funnel-shaped casting, equal in its largest diameter to the throat of the furnace, projects into the interior a depth of 4 or 5 feet; the orifice at bottom, from 3 to 5 feet in diameter, is closed by a conical casting, the apex upwards, from which a chain proceeds to a lever, having a counterpoise at the other end. The materials are filled into the funnel-shaped receptacle, the workman by suitable gearing affixed to the lever lowers the cone, which permits the charge to fall into the furnace. The cone is brought up again by the counterpoise at the opposite end of the lever. The circular space around the funnel, inside the furnace, forms a chamber for the reception of the gases, from which they are conveyed by brick tunnels or iron piping, to the place of combustion.

Where mechanical appliances are employed in filling, this plan is probably amongst the best that can be adopted. It possesses, however, the disadvantage of reducing the available working height of the furnace to an extent equal to twice the depth of the casting at top. The average height of the furnaces where it is in use is 42 feet; consequently, the working heat is reduced to 34 feet.

Another plan, also extensively adopted, consists of a closely fitting lid to the furnace; this lid is lifted up through the intervention of a balanced chain on each occasion of charging. This arrangement causes a less reduction in the working height of the furnace; but the time occupied in lifting the cover, filling in the materials, and shutting close, is very prejudicial to the quality of the gas. It is commonly stated that no gas passes while the cover is up, but this is an error; the same quantity is emitted by the furnace while under blast, whether the cover be on or not; but if open, a large quantity of atmospheric air also passes into the pipes, increasing the bulk of the incombustible gases, and thereby reducing the heating power of the others. In the successful application of the gases, it is a matter of the greatest importance that the supply of gas be regular, and not subject to interruption or variation in quality.

A third plan, in use at several works, is very applicable to existing furnaces. An iron cylinder of 6 or 7 feet depth, and 6 or 8 inches smaller in diameter than the throat, is sunk in the furnace; an exterior flanch on the top for resting on the brickwork inside the tunnel head forms a joint, and maintains the cylinder at a uniform elevation. The annular space between the cylinder and furnace, under the flanch and above the materials, forms a chamber for the ascent of the gases, which are conveyed away in suitable channels.

This plan also has its disadvantages. The duration of the metal cylinder is subject to considerable variation. In some cases it is burnt down in two or three weeks; and under more favorable circumstances seldom lasts more than a few months; consequently, the direct expense of the cylinder, and the delay and expense attending its renewal, are formidable items in the working cost of the gas heating plan.

The disadvantage of reducing the working height of the furnace also attends it. The cylinder is maintained full of materials, it is true, but in consequence of the heated products of combustion, passing into the flues on the outside of the cylinder, out of contact with those materials, they receive only a very trifling increase of temperature in descending the depth of the cylinder. And it must be conceded that the capacity, and thereby the smelting power of the furnace is diminished, by the space embraced within the cylinder and chamber for collection. If the cylinder is immersed 7 feet, one-tenth of the capacity of the furnace will be of no service in the reduction of the metal. The deficiency of smelting power is even greater than this, with the plan first described.

The fourth plan of collecting the gases is considered by some engineers as being the least objectionable. At a convenient depth, generally 8 or 10 feet, an annular flue is constructed around the brick lining of the furnace, with a number of orifices opening downwards into the body of the furnace. This plan leaves the form of the throat and the general arrangements for filling unaltered. From the angular direction taken by the orifices communicating with the interior, they are not liable to obstruction from materials, and the supply of gas is probably more regular than with either of the other plans.

The admission of atmospheric air in certain proportions to the gases, produces an explosive mixture. To avoid such explosions, the pipes and other connections are required to be made air-tight in their joints, to prevent the ingress of dangerous quantities of air during their collection and conveyance to the place of combustion. And to reduce the effects of an explosion, large flap valves hinged in a sloping direction, and kept shut by their gravity, are placed at short intervals in the pipes or flues, for the ready escape of the redundant gas. Yet with these precautions the great force exerted by the explosions constantly occurring in the best-regulated establishments is seen in the dilapidated condition of the erections in connection.

To withdraw a sufficiency, lofty chimney shafts have been erected at several works, and it is now pretty generally considered, that without such chimneys the principle is not applicable to existing works. The long range of piping or tunnelling, through which the gases are conveyed to the boilers and stoves, seems to require additional chimney power to create the necessary draught.

But, notwithstanding the general opinion in favor of the withdrawal and combustion of the gases for heating purposes, we question the practicability of any plan for their removal, which does not interfere more or less with the operations of a furnace working with a minimum yield of fuel. By the experiments made at the Dowlais furnace, we found the consumption of coal in the furnace sensibly increased, while the general quality of the iron was greatly inferior to that previously made. In other works also, we have observed that the consumption of coal in the furnace has increased; in the words of the fillers, "the furnace does not carry so good a burden," and that a similar deterioration of quality has occurred. That such increased consumption of fuel takes place on the withdrawal of the gases, the advocates for their utilization will not readily allow, but as it is a fact, patent to most practical men who have had opportunities of observing the working of furnaces, with and without the withdrawal of the gases, we will endeavor to explain the cause of such increased consumption.

We have already shown the injurious effects which followed the contraction of the throat of the furnace,—a rapid draught being created, and a partial consumption of the coal effected, in a region where its combustion produces no useful result. Bearing in mind then, that a rapid draught at the surface of the materials, no matter how created or maintained, is destructive to the smelting power of the coal, the fact of a greater draught than that usually produced by the ascent of the heated gases being created for their withdrawal, will account for the additional consumption. The effect of immersing a cylinder, or of applying other modes of collection, is to reduce the area available for the ascent of the gases, creating a rapid combustion of the upper stratum of coal, which is met by charging a larger quantity, when it is desired to maintain the quality of the metal unimpaired. To augment the draught beyond the velocity attainable with the powerful chimneys erected for the purpose, the density and volume of the blast has been largely increased in several instances, but this increase of blast, by adding to the existing rapid draught, has still further augmented the consumption of fuel.

The mode of withdrawing the gases through a number of flues entering the furnace at a considerable depth from the top, cannot be otherwise than injurious to the yield of coal and working of the furnace. This mode of collection is in use at several works, but evidently is attended with an increased consumption of coal. The abstraction of the heated gases at a low depth causes a partial combustion of the fuel next to the flues, and deprives the materials above of the useful caloric and carbon of the ascending column; additional coal, therefore, is consumed to compensate for the deprivation of caloric.

But the inquiry is not confined to the greater consumption of

fuel. The quality of the crude iron is deteriorated. From the comparative coolness of the materials above the flues, the conversion of the coal into coke takes place at a very low level, where the rapid evolution of hydrogen, moisture, and other products of distillation, by rendering latent a portion of the caloric, reduces the temperature of the surrounding materials, and disturbs the operations of the furnace. The expulsion of the water and carbonic acid of the limestone is effected at a greater depth; and the changes which the ore undergoes in its descent, commence at the lower level, and occupying a shorter period, the carbonizing influence of the gases and fuel is weakened. Hence, the withdrawal of the gases from a low level is followed by a diminished make of inferior iron, and an augmented consumption of coal.

Effects similar to these, though on a reduced scale, result from their withdrawal from off the surface of the materials at a high level by means of closed tops. The diminished carbonizing power of the coal, coupled with the reduced height of the column of materials, is followed by a corresponding deterioration in the make and quality of the crude iron.

The employment of iron cylinders immersed in the throat of the furnace is attended with another evil, where raw coal is used. The parallel form of the sides retains the coal when expanded by heat, and a considerable portion of its calorific power is thus unprofitably expended. But by hanging in the cylinder for periods of two or three hours, forming as it were miniature scaffolds, great irregularity occurs in the working of the furnace, in addition to the extra consumption of coal. At the Dowlais works, in consequence of the heat evolved by the combustion of the coal within, and that produced by the rapid draught in the annular space between the cylinder and furnace, wrought iron cylinders made of ⅝ boiler plate were burnt down in a few days. Where cokes are used as fuel, we have known similar cylinders last 3 or 4 months, but this last appears to be their maximum duration.

After a careful examination of the various modes of collecting adopted in this country and on the Continent, and having witnessed the alterations produced on the operations of the blast furnace by each, we are of opinion, that it is neither expedient nor profitable to control the escape of the gases; and further, we are of opinion, that, where the consumption of coal is proportioned to the requirements of the case, not one atom of gas, nor one unit of heat can be withdrawn from a furnace, without disturbing the equilibrium of the smelting. This opinion is at variance with the statements of continental chemists, but it must be remembered, that their estimates of the commercial value of the products of combustion, have invariably been drawn from theoretical calculations, founded on experiments in chemistry, and are based on the assumption that they may be withdrawn in quantity, without affecting the smelting; the fact of their with-

drawal occasioning an alteration in the economy of the furnace, has been established in practice. By other calculations, founded on equally unsafe data, the heat capable of being attained by their combustion under ordinary circumstances was greatly overstated; in practice, the maximum working temperature scarcely reaches a third of the theoretical estimate. Altogether the brilliant anticipations formed of the value of these gases for heating purposes, have not been realized, and the policy of withdrawing them for such purposes may fairly be questioned.

But leaving for a moment the propriety of withdrawing the gases, let us see the saving effected, supposing their application results in a saving of the entire quantity of coal usually required for generating steam. For the purposes of the estimate we will take the Dowlais works as a fair illustration of the advantages of the system. The consumption of coal at the blowing engines in those works, averages about 6 cwts. per ton of crude iron.* This coal is the small from the furnace yard and the broken coal produced underground in the operation of extracting the large, and if not used at the engines, would be completely valueless. It is estimated by the proprietors as being worth 1*s.* 6*d.* per ton; 6 cwts. consequently will be worth about 5½*d.*,—therefore the total saving of this work cannot exceed this sum. With the knowledge that the saving must be under 6*d.* per ton, is it good policy to disturb the operations of the furnace with the certain prospect of adding to the consumption of coal? It is thus easy to ascertain the saving, admitting that the application of the gases is successful in generating a sufficiency of steam, but we cannot well form an estimate of the effects on the furnace. There is however one fact which should be well considered; the coal saved from

* Statements have appeared respecting the saving of coal at different works by using the gases for heating the engine boilers, but in the majority of such statements the gases are credited with the saving of such extraordinary quantities that their incorrectness is very apparent. A single instance will suffice to show the kind of reliance to be placed on a mere assertion that a large saving has been effected. The Ebbw Vale company reported their saving of engine coal as equal to 100 tons a week, with 11 furnaces in blast, producing about 1400 tons of pig iron weekly. This statement has repeatedly been quoted as evidence of the quantity of coal which may be saved. Now at the period referred to (1850) this company were using large quantities of coal under their boilers in addition to the heat derived from the gases. The quantity thus consumed, we could not ascertain; but from the figures in the report we learn that a partial saving of the engine coal amounted to a saving of nearly 15 cwts. of coal on the ton of pig iron. Question—The yield of coal at the Ebbw Vale blowing engines prior to the application of the gases? It was also reported that fewer boilers sufficed with gas, yet the number now in use at the different works belonging to this company is nearly twice the number formerly employed. When such reckless assertions are made, it is difficult for those who have not opportunities of personally examining into their correctness to form just ideas of the real value of the gases for heating purposes; and extremely unsafe to quote from them as being reliable evidence on the subject.

under the engine boilers is worth 1*s.* 6*d.* per ton, but the additional coal consumed in the furnace costs from 6 to 7*s.* per ton.

This great difference in the value of the two coals has been altogether overlooked in the theoretical estimates of the value of the gases, yet it greatly reduces their commercial value, and renders more apparent the impolicy of abstracting either gas or caloric from the furnace. An additional consumption of furnace coal of no more than 1½ cwts. per ton of iron, or 3 per cent. on the usual consumption, augments the cost of production in precisely the same ratio as the saving effected by the successful use of gas under the boilers. But 1½ cwts. is greatly under the extra consumption caused by the abstraction of the heated gases; from 3 to 4 cwts., or 7 to 9 per cent. will be nearer the average. Hence, by withdrawing the gases and depriving the materials of a portion of their caloric, a saving of 6*d.* per ton of crude iron is accomplished at the engine boilers by the consumption of a shilling's worth of coal in the blast furnace.

Examined in regard to the saving at the engine boilers for the capital expended, the utility of collecting the gases appears very questionable. We may state that the additional outlay, in boilers, piping, and other erections, averages £1000 per furnace: larger sums have been expended, but we will consider this as sufficient. If the make be estimated at 100 tons weekly, the annual saving will amount to £130,—a sum barely sufficient for interest and working expenses, leaving profit out of the question.

UTILIZATION OF THE CINDERS FROM BLAST FURNACES.

Unlike the gases, the utilization of blast furnace cinders early engaged the attention of practical men. Hitherto, however, all attempts to convert this substance into articles of utility have failed,—in a commercial point of view. It is capable of being moulded into the most intricate forms, and by a judicious disposition of the colors, be made to assume very beautiful appearances; care, however, is required in the annealing operation; for unless this is successfully accomplished, the articles are of a weak friable character, and incapable of withstanding sudden changes of temperature. But notwithstanding the acknowledged utility and beauty of the articles manufactured from the liquid cinder, the successful application of this substance—produced at the present time at the rate of nearly seven millions tons per annum—to useful and ornamental purposes, is surrounded with difficulties of no ordinary character.

One of the chief drawbacks to its employment for articles of permanent beauty lies in the metallic iron in combination,—common to all varieties of cinder produced in the manufacture of iron. When moulded and annealed, numbers of the blast furnace cinders are in appearance little inferior to the finest serpentines and marbles; but unlike these stones, they do not retain

their beauty. After a brief exposure to atmospherical changes the combined metal at the surface is oxidized, and the articles are forthwith covered with a coating of rust, of less or greater thickness, according to the percentage of iron in the crude cinder.*

For buildings and other purposes wherein permanent beauty is of secondary importance, they have been partially applied for a lengthy period. Their perfect annealing, however, involves a consumption of labor, coal, and capital, which, by enhancing the cost of the blocks, prevents their successfully competing with the more common building materials, except under very peculiar circumstances; for, owing to the bulky nature and low value of the produce in this form, the cost of freight limits its application to the locality of production.

And in any invention or proposition for the utilization of cinders, it must be borne in mind as a primary consideration, that the ironmaster's peculiar province is the extraction and manufacture of the metallic iron in the ore. Whatever value the waste products of any one process may possess, unless it can be made directly subservient to the manufacture, it is of doubtful utility to the ironmaster. If the blast furnace cinders possess a commercial value (and, in our opinion, the metallic iron which they contain constitutes their chief value to the smelter), it must be considerable, its realization unattended with expensive plant, and above all causing no interference with the working operations of the furnace, or administrative arrangements of the establishment; or, in a pecuniary view, it cannot be a profitable undertaking to the smelter.

[To be continued.]

ART. III.—GOLD ORES AND THEIR WORKING, No. 3.

(Continued from page 275. Vol. 7.)

As in the pursuit of the natural sciences, one branch of study is more than sufficient to absorb the undivided attention of one who is desirous to investigate; and to insure success in the researches to be conducted, but one division should be closely followed, ex-

* An American patentee, W. H. Smith, proposes a system of refining by subsidization and chemical agents, by which, it is stated, the liquid cinder is resolved into strata of varying qualities; the lowest being most dense and valuable for commercial purposes. The refining by chemical treatment is applicable to limited quantities only; while the treatment by mechanical subsidization necessarily results in the lowest stratum containing the largest percentage of iron—hence its superior density renders it more subject to deterioration by oxidation.

amining all others so far as to be familiar with their general principles, and their immediate relative bearing upon the one chosen for examination: so in the investigation of mineral veins, those belonging to one class of metal only, should be made the object of rigid scrutiny and constant attention; studying all others as correlatives, and in their general features and principles. The study of iron, alone, will occupy a life-long experience; while that of lead, tin, copper, or gold, will each of them require an equal extent of time. To be able to merely describe the phenomena of any one class of veins, without attempting to explain the causes of the witnessed effects, would, if they were faithfully and accurately portrayed, swell the narrative into volumes of no inconsiderable numbers, or of no very limited size.

The experience of a few years passed among the gold-bearing veins, has taught me that a vast and almost unknown field lies open for investigation and discovery; and it is a matter of no small surprise, that the veins which produce that metal, which ever stimulates the individual or the nation to active exertion, should have met with so cursory an examination. Man, in his anxious haste to obtain gold from the veins, has lost sight of the necessity of comprehending the laws of those veins, as an aid to the realization of his desire; and often, from his deficiency in that knowledge, has left unworked a rich field at his own threshold, to vainly seek in distant climes the realization of the high-colored pictures of an over-excited imagination. I hope that period is not far distant, when this important field shall meet from men of intellect and energy, that study and research to which it is so justly entitled.

The great gold field of the Atlantic slope may be said to extend from Newfoundland to the Gulf of Mexico; gold having been found at various times in the British Provinces, in the Eastern, Middle and Southern States. Wherever the primitive rocks are exposed, throughout this extensive region, it is highly probable that gold can be, if it has not already been, found. In many sections, the most careful research would perhaps show but a meagre trace of gold, while in others the quantity would vary from a sufficiency to barely repay the expense attendant upon its extraction, to an amount which would be highly remunerative to those engaged in its pursuit. The primitive rock of this field appears to be divided into two great belts; one, granitic; embracing all the varieties of that widely extended class; the other, talcose slate, in every modification of constitution, from that tenacious and indurated form of the green-tinted slate in which silica mostly abounds, closely approaching hornstone in its character, to the more friable and easily broken shale, in which micaceous scales predominate. The granitic rock appears to prevail in the Northern or upper portion of the gold-bearing region, while the slate chiefly obtains in the Southern or lower section.

The extent of this vast field has never been accurately delineated. In some portions, I have traversed it, at right angles with its course, over eighty miles, and then have not passed entirely through it. On many tracts not a square acre could be examined, but that gold would be found; and as future explorations shall proceed, it is highly probable that even richer locations than any now known, will be discovered. My own belief, founded upon the knowledge obtained by personal examination and close inspection of the one field, and by the opinions derived from persons whose observations have extended over both, is, *That ultimately the gold field of the Atlantic States will produce more of the precious metal, than will be obtained from the gold field of the Pacific Coast.* Bold as this assertion may appear, I find it is concurred in by many who are familiar with each field, and partially corroborated by the facts, that many who have visited California, are now returning to the Atlantic States, to prosecute their labors, with the conviction that their exertions will meet with a better reward here; and, that the gold is more equally distributed throughout this field than in that. There certain locations are exceedingly rich, here the yield is more uniform.

Hocheder gives it as his opinion of a gold formation: "That it is limited in its horizontal course, forming a *band* dipping parallel with the stratum, but inclining toward the lower level of the country." He speaks of the above as "a general law" of gold veins. He appears to think that the gold diminishes beyond a certain depth. He says, "In Europe we find most riches in the *middle depth;* that is, from seventy to eighty fathoms. Before reaching that depth the riches are increasing: and in the same proportion diminishing after having passed it."

Causes which are still in active operation, have produced the decomposition of the granitic rock, and of the slate series, to a depth varying from a few feet to over two hundred feet. This decomposition, at and near the surface, has reduced the original rock to a tenacious clayey soil, strongly colored with oxide of iron. This soil usually extends from the surface downward about ten or twenty feet; from thence the change is gradual, from a coarsely constituted crumbling mass to the indurated rock. The average depth of reaching the solid rock is about eighty feet. I have been over one hundred and fifty feet down, without passing through the soft gneissoid rock. The question has been raised, if this rock ever was indurated, and whether it is not in an imperfect condition. The phenomena of its decomposition are too numerous, meeting the attention of the observer at every step, to allow him to entertain this opinion. The hardest class of this rock will, when exposed to the changes of temperature, and from moisture to dryness, of the atmosphere, speedily crumble into an earthy mass. I laid bare, in the early part of the winter, a long line of rock, to break which the drill and powder were necessary;

at the close of the season, the decomposition had extended some two or three inches into the rock, the quartz had become broken and divided, the feldspar crumbled to a white powder, and the mica reduced to a comminuted mass. The softening or crumbling of the rock extends, as stated above, through every grade, from a fine soil, to its final blending into the hard and well-formed rock. The shafts seldom require timbering in this decomposed rock, it being amply tenacious to hold good for several years; a single set of timbers to protect the mouth of the shaft, being all that is required. I have seen hundreds of shafts, and have been down in many of them, that have stood for some years, and are now as sound and perfect as at the time of their construction.

Throughout the whole field trappean dykes are of frequent occurrence; in some places producing no apparent disturbance in the adjacent rock, in others being accompanied with "heaves" in the veins, and violent contortions in the strata. In many instances immense nodules of greenstone, formed of a series of concentric strata, like the layers of an onion, are imbedded in the granitic rock, invariably accompanied with marked derangement of its stratification. In some locations nodules of trap, from four to twelve inches in diameter, are abundantly scattered over the soil, and at first glance appear like water-worn boulders, but a slight examination evinces, that the roundness of form is the result of gradual decomposition, and not of attrition.

The "*deposit washings*," or the beds of gravel, with auriferous particles interspersed through them, from their being the earliest worked, may properly be placed the first on the list of gold locations. Most of the deposits bear evidence of the action of water, in the rounded form of the pebbles of which they are composed; all of this class are found in, or near, the present line of water-courses, and have been transported by aqueous power, from their original to their present position, and their surfaces are worn smooth by the consequent action. Another class of deposits is formed also of rounded pebbles of quartz, which are imbedded in a white siliceous sand; these pebbles are formed by the gradual disintegration of the quartz fragments, which originally constituted the gangue-stone of a vein, and the white sand is the result of that segregation. These deposits are invariably found in close proximity to a vein, from which, by the gradual wearing away of the surrounding rock, they have fallen. The surface of the gravel of this class is granular and rough to the touch, by which feature it is distinguished from the stream deposit. A third variety is one which is every where abundant in the gold field, and is made up of sharp angular fragments of quartz, which have broken down from a vein, and have neither undergone disintegration nor transportation. The vein is always closely at hand from which they are derived. The largest portions or "nuggets" of gold are found in the deposits, either isolated, or attached to loose boulders,

while the gold obtained from the veins is either in exceedingly minute particles, or small but coarse grains.

Owing to the gradual change which has occurred in the surface conformation of the great gold field, the water-courses of the present day hold a much lower relative level, than they primarily possessed; and, in consequence, beds of gravel are now found in elevated positions, and occupying, not only the slopes, but also the rounded summits of gentle and sometimes abrupt hills. Viewed solely in reference to their present position, it would be difficult to account for their occupation of such elevated locations; but it ceases to be a matter of mystery, when the past and present surfaces are compared. There is but little, if any, perceptible difference between the thickness of these gravel beds, on the summits or sides of the hills, and the thickness of them in hollows or depressions. In the immediate line of the present water-courses, the gravel accumulations are sometimes very considerable; varying from two to twenty feet, in the more elevated locations, they range from one and a half, to three and four feet, in thickness. In many of the deposits of coarse gravel, the quartz fragments have a granular loaf-sugar-like construction; in this quartz, although invisible to the unaided eye, gold is disseminated in quantities that will pay to work it. This quartz appears like a compact aggregation of siliceous sands.

In McDowell County, North Carolina, where the most extensive sluice washings in the State are now in successful operation, and where, consequently, the gravel beds are fully exposed to view, the auriferous gravel reposes directly upon the primitive rock, and appears to maintain a somewhat uniform thickness of its bed, even upon the sides of very steep hills. This gravel is in all cases covered with a bed of soil, from one to ten feet deep, highly colored with ferruginous oxide, and containing a small quantity of fine gold irregularly disseminated through it. From the rock on which the gravel rests, no gold is obtained, except from veins which pass through it.

Each stream that flows on its way, from the mountain slopes to its final discharge in the ocean, bears in its current its destined burthen of earthy particles and fragments of rock. Its turbid waters are silently, slowly, but surely, effecting a change in the country through which it winds its course. When we look back upon the countless series of years that have passed away, since the "dry land" was made to appear above the "waters of the great deep," it requires no vigorous effort of the imagination to conceive the important changes that this constant degradation has produced. The question might not inaptly be here introduced, as to what extent this degradation has proceeded, but as it is my intent to render these papers strictly practical in their nature, and to confine them to a simple record of facts, I must necessarily avoid all hypothetical disquisitions, regardless of the

deep interest and attraction by which they are surrounded. The conviction to which I have been led by various examinations, is, that the original level was above two thousand feet higher than the present surface.

The veins which intersect the granitic rocks are usually siliceous, being composed, more or less, of the cellular or cavernous quartz. The quartz is sometimes of a milky hue, and compact; at others, of a grayish blue tint, and either lamellar, or with a strong tendency toward that character. When lamellate, the planes are usually coated with a snuff-brown oxide of iron; this class of ore is generally very rich. The gold is frequently visible when the laminæ are separated, and occurs in such instances, in fine flattened grains. The quartz occasionally is semi-transparent or resinous, and when in this condition, is generally unproductive. Opaque crystals are sometimes found in the cavities of veins, upon the surface of which the gold is deposited in a beadlike form. A bright pink-colored quartz also abounds in some veins, deriving its hue from the infiltration of a ferruginous solution; if freely charged with iron pyrites, this ore is very valuable; if deficient in the sulphuret of iron, it bears a very meagre and unimportant character.

Some veins are highly charged with bright, glistening iron pyrites, of a cubical form; sometimes, with the pyrites of a dull black color; at others, with the pyrites reduced by decomposition to a brown oxide of iron, in all stages, from a soft and almost impalpable powder, to a hard compact nodule. Where the decomposition of the wall-rock has not extended, the pyrites usually remains in its original form, and with its brilliant surface; but it passes through every grade, from that state to the soft powder, as the decomposition of the wall-rock has more or less progressed.

Some of the cavities of quartz carry the pure flowers of sulphur; which, like those formed in the laboratory, are shown by the microscope to be an accumulation of minute crystals; in such instances the iron has disappeared through the compact mass of quartz which surrounds the cavity.. This semi-transparent quartz is firm and solid, no aperture existing through which the metal can have found an exit; the form of the cavity clear and distinct, the angles of its sides being as sharp and well defined, as if cut with the greatest nicety and precision by the utmost perfection of mechanical skill; the silica entirely free from metallic stain, evincing not the slightest trace of iron, and holding within these cavities a few grains of beautiful sulphur, and frequently, also, a few small particles of gold, either in a granular or leaf-like form; most commonly the latter. This cavity originally held a crystal of auriferous sulphuret of iron, as is clearly proved by its form; by the presence of the sulphur and the gold, and by similar-shaped crystals of pyrites being found imbedded in the same rock. What

mystic power has conducted this process so perfectly, and evidently so quietly, as not to disturb the construction of the siliceous mass? The undisturbed angles of the accurately cut cavities, with the refractory nature of the silica, are potent proofs adverse to the idea of fusion; while the freedom from stain or mineral tint, of the surrounding quartz, together with the fact that the silica is impervious to water, removes all foundation upon which to maintain the argument in favor of solution. That which adds to the mystery, and tends to complicate the phenomenon, is, that vacant cavities will be in juxtaposition to some, from which the pyrites have not been wholly removed. A cavity holding only the flowers of sulphur, will be divided from a perfectly enclosed crystal of sulphuret of iron, by a thin film or partition of quartz, no thicker in some instances than the paper upon which I am writing. The action progressed in one, and not in the other instance. In some cases only a portion of the iron pyrites has been removed; and here only the iron has disappeared; its combining sulphur has been left behind with the unremoved pyrites.

The sulphuret of iron, or iron pyrites, although one of the most common and widely diffused minerals, is perhaps, in reality, one of the least understood. Its combination is still a matter of question, not that any doubt exists as to its being formed of sulphur and of iron, but the peculiar state in which they are combined, the condition of the iron at the time of, and during the continuance of the combination, are points which have never been clearly elucidated. It may appear strange that a mineral, which is one of the most frequent associates of all mineral veins, should not have met with more close and direct research; but when it is remembered that except in gold, and rarely in silver veins, the pyrites is generally discarded as being useless, so far as its intrinsic worth is concerned, it will not be a matter of as much surprise, that it has not received that attention, which in reality it truly deserves.

If the pyrites from the gold veins which has passed through the ordinary process of crushing, amalgamating, and washing, and from which all the gold has been extracted that it was possible to obtain, should be saved and placed in heaps, where it would be subjected to the alternations of temperature, dryness and moisture, of the atmosphere, it will undergo a change or decomposition, after or during a few months' time, and by its still more perfect disintegration more gold will be liberated; and if the sands are again subjected to the process of amalgamation and washing, a second yield of gold will be obtained, which in some instances will equal that produced by the first manipulation. I have seen sand worked in this manner the sixth and seventh time, and still pay for working. A minute quantity only of the pyrites undergoes decomposition each time; much of it is lost by being washed away in each operation.

There is a considerable proportion of the pyrites that will not readily decompose; this is not magnetic, and the sulphur bears the proportion to the iron, of two to one. The smaller portion is susceptible of rapid decomposition, and when first reduced to a pulverulent state, contains some particles of iron that are attracted by the magnet; and as oxide of iron is not magnetic, it is reasonable to suppose, that a portion at least, of the iron, is in a metallic state. This class of pyrites is formed of equal quantities of iron and sulphur. Hatchett expresses the opinion, formed from his investigations of the iron pyrites, that it is an aggregation of sulphur and iron, and not a chemical compound. Sulphuric acid will act upon the magnetic pyrites but not upon the common class. Nitro-hydrochloric acid only, will attack the bi-sulphuret of iron. P. M. Johnson states, "That if iron pyrites is calcined in the open air, it suffers a loss of one half of the sulphur, which passes off as sulphurous acid gas. * * * * If the pyrites be first ignited, and then allowed to burn of itself, one fourth of the sulphur passes as sulphurous acid, being made to combine with the oxygen consumed in combustion, one fourth is collected as sulphur in close chambers, and one half remains in combination, forming proto-sulphuret of iron. * * * * If the pyrites is calcined in close vessels, then half the sulphur can be collected, no sulphurous acid is formed, but the remaining half forms proto-sulphuret of iron which remains in the retort." By the spontaneous decomposition of the pyrites, when thrown into heaps, after undergoing the milling process, sulphate of iron is freely formed. The heaps will often be completely covered with aggregations of minute crystals of this salt, which lose their water of crystallization by exposure to the sunshine, and crumble into a fine ash-gray powder. An atmosphere varying in temperature and moisture affects the pyrites most.

Now if any feasible plan can be discovered and adopted to divest the pyrites of one half of their sulphur, the working of gold ores would cease to be problematical, as to the question of profit. But this plan must not consist in the common method of roasting, for the loss entailed by such a course is greater than the gain. The experiments instituted by the Russian Government, prove that the roasting of the ores is attended with a serious loss of the gold. This fact appears also to have been understood over two centuries ago. Lazarus Erckern, Assayer-general of Germany, published a work descriptive of ores and metallurgy, at Antwerp, in 1629. This was translated and republished in London, in 1683, by "Sir John Pettus, of Suffolk, Kt." I quote from the translation: "But the poor *Gold* Oars which are mingled with small Gold (and cannot be parted with the hand) the same if they can be wrought without *Roasting*, may be *Bucked* and prepared two wayes." Again: "That such *Flints* and *Horn-stones*, * * * may in a special *Roast Oven*, made on purpose, be burnt." After

describing the close ovens, he says: "Also the heat of the fire remain together in the Oven, and force itself through it to the top of the *Furnace*, and such forced and inclosed *Heat* doth much more than in an open *Roast.*"

M. Boussingault says: "The exposure to the air of the previously washed pyrites is equally well calculated; by this exposure a portion of the pyrites passes into the state of a sulphate, which is carried off by the rain; the atmosphere principally acts upon the minutely divided sulphurets; for after being exposed for several months to the air, the heaps of minerals diminish in volume, and the remaining pyrites are in minute fragments, the greater part of which possess the cubical form. The first idea which presents itself in order to diminish the pyrites in volume, is to place them in favorable situations to decompose with rapidity; the pyrites would then pass into the state of sulphate, which would afterward be dissolved by water. Unfortunately the cubical pyrites, at least those of Marmato, appear not easily to decompose, for after a very long period their decomposition is only partial."

Leah, of Mino Vellio, says: "If we could only effectually oxygenate the sulphur and arsenic; or volatilize them by heat, or unite them with any earthy or alkaline base, the amalgamation of the auriferous contents of this concentrated mineral could then, I am of opinion, readily be accomplished."

One of the older writers, Kirwan, says: "According to Rome de Lisle, one and the same species of pyrites exposed to moist air effloresces and vitriolizes, and, exposed to dry warm air, suffers a gradual decomposition by the loss of its sulphur without any alteration of its shape, and by absorbing fixed air is converted into Brown or Hepatic iron ore."

In Thomson's Inorganic Chemistry it is stated, "That iron united to a portion of sulphur, forms a brittle compound soluble in muriatic acid, and susceptible of magnetic impregnation; saturated with sulphur, the compound becomes brittle and insoluble in muriatic acid, and destitute of magnetic properties. Sulphuret of iron may be obtained also where iron pyrites is distilled at a red heat; one half of the sulphur flies off and leaves sulphuret of iron. The mineral called magnetic pyrites is a combination of five atoms of sulphuret of iron and one atom of bi-sulphuret. The addition of a certain portion of sulphur likewise renders iron susceptible of becoming a permanent magnet. The sulphur may amount to 46 per cent. without destroying this property, but when it is increased to 52 per cent. the magnetism vanishes completely. Some varieties of iron pyrites are not altered by exposure to air, while others, when so exposed, split in pieces and are gradually converted into sulphate of iron. Probably those varieties which are thus decomposed contain some sulphuret of iron mixed with the bi-sulphuret."

From the above quotations it will be perceived that at present the most feasible plan of acting with the pyrites, is to allow them to gradually decompose under atmospheric influences. It is to be hoped that more speedy means may ultimately prevail.

The "brown ore," as it is commonly termed, is a peroxide of iron resulting from the decomposed sulphuret of that metal, and in all mines is considered as the richest class of ore. There are two kinds of brown ore, however; the one, "lively," containing gold; the other, "dead," which has become so far decomposed as to be devoid of value; the gold, by some agency, having disappeared from it. This phenomenon is one of the mysteries of the gold veins. The brown ore, which contains gold, will, after exposure for several years, be found to have entirely lost its treasure; and that too, while it retains its original form, and occupies the cavity it ever held, in the quartzose gangue-stone. Gold, the least oxidizable metal, disappears the first. A practical eye can at once discern which is "dead" and which is "lively;" but yet it would be an impossibility so to describe the difference between the two, as to enable any one not familiar with the ores, to decide to which class a specimen belonged, by reading the description.

When the "lively" brown ore is fractured, bright particles of gold are frequently visibly interspersed through it, and when the gold is not visible, by panning the ore, the fine auriferous dust will evince a rich yield.

Some veins afford singular and beautiful specimens of brilliant black and iridescent hematite; frequently stalactitical; the nucleus of the stalactite often being a fragment of snow-white quartz. This hematite carries particles of gold upon its surface, and interspersed through it.

The quartz will be sometimes charged with galena, sulphuret of copper, and traces of zinc blende.

The lead-bearing veins usually contain silver as well as gold. I was informed at the Branch Mint at Charlotte, N. C., that all the gold brought there contained a variable percentage of silver; and that the gold that came from the Southern side of the great belt contained the most silver. The purest gold brought to the mint was worth $1.02 per dwt., while much would not be valued at more than 70 cents.

Those veins which are charged with copper are usually rich in gold, above the water level of the country; the decomposition of the rock not having advanced below that point, the gold has not been liberated, and is consequently more difficult to obtain from the ore. In that part of the gold field where copper is prevalent, I question if the veins that have heretofore been worked for gold, are not, all of them, indexes to copper lodes. Most of these mines have been abandoned by their proprietors,

when the copper ores became so abundant as to interfere with their operations for gold.

Sometimes in breaking a piece of compact quartz, a coarse grain of gold will be found imbedded in it, totally unaccompanied by any other metal. In such cases the edges of the grain are sharply and clearly defined; proving that the gold could not have been subjected to the abrasive or wearing influence of water.

At the King's Mountain Gold Mine, coarse-grained gold is found imbedded in *crystalline metamorphic limestone;* a rare and peculiar phenomenon. This is caused by the intrusion of the limestone into the vein, which at this point is much disturbed.

The general course of the gold veins is from 20° to 40° East of North, by 20° to 40° West of South. The usual dip, or underlie, varies from 40° to 85°, in most instances to the North. I find that, facing the Easterly course of the vein, the "slides," "jumps" or "heaves," all synonymous terms, are all to the South, or on the right hand for the upper portion of the vein; as shown in the annexed section of one of the veins in the Rutherford Mines in N. C.

Two such heaves there occur upon one vein at a vertical distance of about forty feet. In each case the lower portion of the vein assumes a more vertical position than it maintained in the upper.

The width of the veins varies from one or two inches, to six or eight feet. Their average width is from eighteen to thirty inches. I measured one vein which is yet unworked, the width of which was over twenty feet, and which vein I traced over half a mile, and could have undoubtedly followed its course still further, had I not reached the line within which my exploration was restricted. The High Shoal Vein, near Lincolnton, N. C., at the surface is about two feet wide, while at a depth of one hundred and thirty feet, it is from six to eight feet wide. The average value of the ores of the granitic section, may be estimated at from twenty-five to fifty cents per bushel; which, estimating twenty bushels to a ton, would give a value of from five to ten dollars per ton.

The veins in the Slate Belt are sometimes quartzose, in which case they closely resemble the veins in the granitic rock; at other times they are not marked by any difference or change from the surrounding rock; in this case they cannot strictly be called veins, but merely an impregnation of the laminae with the auriferous particles; in such positions, however, the usual accompaniment of oxide of iron alway makes its appearance, in the form of a thin brown dust, or coating of the contiguous sheets of slate. The gold is in flattened grains with accurately defined edges, evincing a total absence of drift or wash. In the interlamination of the slate, or the extension of the smaller fissures

transversely to the true laminae, the gold is also visible; but never in the compact body of the slate itself. The value of the ore varies very much, sometimes in the space of a few feet, and even a few inches. In the slate veins, therefore, constant watchfulness is to be observed, that all changes in value may be immediately known; else a worthless rubble may be accumulated for ore, or good ore may be unwittingly wasted. The ores will bear the same average value as those of the veins of the granitic rocks. In some instances the value has been over one hundred dollars per bushel; unfortunately those which reach this valuation, are by no means abundant. Rich portions of the vein may sometimes occur, from which, in a brief space and time, very valuable returns may be obtained; but such points are not to form the basis of calculation; for gold-mining, legitimately practised, will require constant scrutiny, rigid economy, and the same close attention that any other branch of business would demand to ensure success. This slate belt holds some very important points, that have been worked and are still favorably known to the public as rich mines; Dorn's mine in South Carolina, the Lawson and Howie mine, and the Gold Hill mine, in North Carolina, may be named as instances. There are many locations upon the course of this slate belt, which I have visited, the surface indications of which bid fair, when they shall be worked, to win a high name and reputation in public estimation.

The yellow sulphuret of copper is prevalent in most of these veins, and will ultimately be a paying portion of the mines when they shall be more deeply worked. There is found in these veins a triple carbonate of iron, lime and magnesia, of a snowy whiteness when first raised, but gradually assuming a brown tint upon exposure to the atmosphere.

The slates afford a great variety in color; even in a section of a few feet giving tints of ash gray, white, pale blue, purple, pink, lavender, light and dark red, brown, pale green and yellow. In fact so great a diversity of color exists in various strata, that the unpractised observer would be liable to consider each color as a separate variety of rock; but by close examination it will be found, that the same stratum, at different points holds every variety of hue, and that all merge at last into the one great slate of the belt. May not the various colors which are so prevalent in the soil, immediately contiguous to the gold veins, owe their presence to the coloring power of the gold? This is an interesting question, and I can but hope it may, if it has not already done so, attract the attention and promote the investigations of others. Is there any connection between the phenomenon and the following facts?

Bequeret, on the chemical decomposition by voltaic action, says: "It was long supposed that gold was converted into a purple oxide by means of electric discharges; but it appears

that this state is only the effect of the extreme division of its parts, as it cannot be admitted that it is oxidized at the temperature at which its oxide is commonly reduced. It tends to confirm this conjecture, that when gold is precipitated from a very weak solution, we likewise obtain a purple powder, by means of bodies which reduce its oxide."

"If the charge of a powerful electro battery be passed through an exceedingly fine gold wire, it becomes entirely dissipated; and when a sheet of white paper is held beneath it at the time of discharge, it becomes stained with a purple line, caused by a deposit of minutely divided gold."—*Phillips' Metallurgy.*

"Its only solvent is aquaregia; the solution contains perchloride of gold, and imparts a purple color to the human skin." —*Rose.*

"M. Bontemps says that gold, which is used in glass coloring for the purpose of imparting varieties of red, was found by varying degrees of heating at a high temperature, and recasting several times, to give a great many tints, varying from blue to pink, red, opaque yellow, and green. * * * * Mr. B. is disposed to refer these chromatic changes to some modifications of the composing particles, rather than to any chemical changes in the materials employed."—*Hand Book of Useful Arts, page* 216. *Putnam*, 1852.

"Chloride of gold at first produces no precipitate; after some time the liquor assumes a slightly greenish tinge, and a small black precipitate falls down. This insignificant black precipitate consists of metallic gold in an extreme state of division."—*Rose.*

"The addition of this alkali almost constantly determines an immediate deposition of gold under the form of a black precipitate; the black color of which is so deep that, judging by the color, one could hardly conceive it to consist of the pure metal. * * * * The black precipitate is alway more promptly determined by the aid of heat."—*Rose.*

"In presence of an excess of potash, almost all organic substances, precipitate gold from its solution in the metallic state and under the form of a black powder."—*Rose.*

(To be continued.)

Art. IV.—On the Causes of the Serious Loss of Silver which Occasionally Takes Place During the Roasting of Silver Ores.—By Prof. Plattner.

It has been long known from experience, that during the roasting of silver ores and furnace products in a finely divided state, in addition to the mechanical loss of silver through the formation

of flue-dust, there also occurs a loss by direct volatilization, varying, according to the properties of the ore, from 1 to 10 per cent., and in argentiferous blende, exposed for a long time to a strong calcining heat, amounting to much more. These facts give rise to a question which may be divided into two parts, namely,—1st, How does it happen that in ores containing an equal percentage of silver, but of different qualities and composition, the loss per cent. in silver differs when they are subjected to the process of roasting? And, 2dly, In what condition is the silver volatilized?

To solve the first part of this question, many experiments were made, on the small scale, by the author, in the following manner:—Various substances, for the most part quite free from silver, were reduced to a fine powder, and mixed with other substances rich in silver, and also in fine powder, in such proportion that the mixture should contain from 1 to 2 per cent. of silver; these were then exposed to the action of heat and atmospheric air, in capsules of clay. For this purpose a muffle was used, heated to dull redness, and most of its openings closed so as to allow of a very moderate circulation of air within it. The heat was gradually raised until it reached the temperature at which sulphate of copper is slowly decomposed. The substances used to mix with those rich in silver were pyrites, blende, various anhydrous metallic sulphates and metallic oxides, and finely powdered quartz; those rich in silver were sulphuret of silver, light and dark Rothgiltigerz (pyrargyrite and proustite), metallic silver, sulphate, arseniate and antimoniate of silver, all in fine powder.

These substances were roasted from three-quarters of an hour to an hour and a half, and then assayed for silver in the usual way; but in order to ascertain more accurately the amount of silver which should have been obtained from them, an equal amount of the unroasted ore was assayed with equal quantities of lead, so that the slight loss always occurring from the absorption of silver by the cupel ("Kapellenzug,") would be the same in each case; the loss of silver during the roasting was then found by comparing the weight of the two buttons.

The results of these experiments showed:—

1. That the loss of silver in question was occasioned chiefly by chemical causes.

2. That a volatilization of silver appeared to take place when the silver in the ore either passed from the state of sulphuret into that of metal, or when the oxide of silver, in combination with sulphuric acid, again suffered decomposition.

The loss appeared to be greatest in light, loosely aggregated substances, whose particles had little cohesion and were not disposed to sinter together, as they were more readily penetrated and traversed by the atmospheric air.

3. That the loss of silver was greater when the roasting was protracted, if at the same time the temperature was increased.

4. That the loss was increased when magnetic oxide of iron or suboxide of copper exercised a reducing action on sulphate of silver.

5. That generally the loss of silver was greater when the silver existing as sulphate was exposed to a protracted roasting at a high temperature in company with free metallic oxides, than when it was present as arseniate or antimoniate of silver. The reason of this is, that the sulphate of silver is decomposed and reduced to metallic silver before either of the other salts, and more particularly before the arseniate, although their behavior at a high temperature is not altogether the same, as the antimoniate of silver is very rapidly decomposed, the other two salts more slowly.

With regard to the second part of this question, (in what condition is the silver volatilized?) the following experiments on the small scale were instituted by the author:—

1. 3 grms. of silver, in a minute state of division, were carefully mixed in a glass mortar with an equal volume of finely powdered quartz; this mixture was introduced into a glass tube ¼ an inch wide, and about 20 inches long, of difficultly fusible glass. And after that part of the tube which contained the mixture had been enveloped with platinum foil in order to ensure a more uniform application of the heat, it was raised by means of a spirit-lamp to a moderate red heat (incipient *strong calcining* heat), while from a gasometer a current of dry hydrogen gas was passed slowly over it. Although this experiment was prolonged for upwards of an hour, not the slightest appearance of volatilization of the silver could be perceived. 2. An experiment, conducted in the same manner with carbonic oxide, led to the same result. But, 3, when a similar mixture was treated with oxygen gas, there quickly appeared in the neighborhood of the mixture, towards the open end of the tube, a slight, dull, grayish-white coating, which gradually increased, and extended about an inch along the tube; afterwards, that portion of the coating nearest to the mixture was converted into a shining, annular, metallic crust. At the conclusion of the experiment, which, like the former ones, was carried on for an hour, a portion of the sublimate was removed, and on rubbing it in an agate mortar was found to be metallic silver, and this was confirmed by testing in the wet way. The part of the glass tube where the mixture had rested was found to be stained of a light to a dark yellow by oxide of silver, both above and below, and a little to the right and left of it. 4. A mixture of finely divided silver and ignited oxide of zinc, treated in the same manner with oxygen gas, gave in general the same results; the metallic coating, however, was not quite so striking; the tube also was found to be colored yellow, by oxide of silver, where the mixture had rested.

From the results of the above experiments we may draw the

conclusion, that that portion of the silver which, in addition to that carried off as flue-dust, escapes during an oxidizing roasting, is removed, not in the metallic state, but at a certain temperature commencing at a low red heat, as oxide of silver, which afterwards, in its free state and at a low temperature, is again reduced to metallic silver; but as it then exists in such an extremely minute state of division, it becomes mixed with the gaseous products of the combustion of the fuel, and also the gases and vapors resulting from the oxidation of the ores, and is readily carried away with them into the atmosphere.—*Berg-undhüttenmann Zeitung*, 1855, No. 35.

ART. V.—VISIT TO THE LAKE SUPERIOR REGION IN 1854. By L. E. RIVOT, Prof. of French School Mines No. 6.

(Continued from page 255, Vol. 7.)

BEFORE speaking of the Alluvium which covers a great portion of the country, it seems to me to be useful to review in a few words the geological constitution of the borders of Lake Superior.

We meet at Lake Superior with rocks of three distinct characters.

1st. Rocks deposited primitively under water in horizontal beds—the magnesian limestone; the sandstone and the conglomerates.

2d. Trap, the igneous origin of which is still doubtful.

3d. Granites and metamorphic rocks, the appearance of which has certainly followed the deposit of the other series.

Granite and the metamorphic rocks appear to constitute the mountains on all the eastern portion of the Lake. Towards the north they form at a short distance from the shore a very elevated chain, the direction of which is sensibly parallel to that of Isle Royale, N. 65° E. to S. 65° W. The trap and the dislocated elevated sandstones of this chain do not leave any doubt that the granite has been the upheaving rock, at least in this part of the Lake.

Upon the Southern shore, the granite covered in part by the micaschist, the jasper of the amphibolique rocks, appears around the shore south of Keweenaw Bay and extends into the State of Wisconsin, in a direction S. 70° W. There again the series have been broken and elevated by this rock; for we find at the north as at the south, sandstones in horizontal beds at a certain distance from the granite, dislocated and elevated in contact with that chain of mountains.

It is very easy under the present state of the explorations made in this country, to put forth an opinion upon the primitive nature

of the amphibolic rocks in contact with the granite and designated by American Geologists as metamorphic.

The trap under various varieties, as compact, granular, amygdaloid, crystalline, and porphyritic, presents itself in powerful parallel beds, likewise parallel to the conglomerates and sandstones, and separated very frequently from each other by some layers of these two sedimentary rocks.

It appears along the coast of Canada on the east and north; at Isle Royale and upon the American coast, from the extremity of Point Keweenaw, far to the west in Wisconsin.

At the north the trap is dislocated and elevated in contact with the granites. At Isle Royale the beds are inclined towards the south from 10° to 12°, and dip under the waters of the Lake, covered in part by the conglomerates and sandstones.

At Point Keweenaw the disposition of the trap is somewhat complex, and its direction is not as regular as at Isle Royale. The direction of the beds presents many inflections to which the transverse fractures of all the series seem to correspond, and it varies from E. to W. even to N. 10° S. E. and S. 10° W.

Through its whole extent the trap is divided into two parts by a chain of mountains, which in general is nearer the southern limit of the Zone; the southern slope presents in all its beds an inclination towards the north, at an angle varying from 55 to 25°; on the opposite slope the slant is southerly at an angle from 30° to 64°. This arrangement proves that the beds of trap have been broken according to the direction of the chain of mountains by a rock which has elevated them without coming to the surface. We can conjecture that this upheaving rock is granite, by the analogy with the respective positions of trap and granite upon the northerly shore in Canada, and west at the boundary of Minnesota.

The Porcupine Mountains west of Ontonagon represent a partial upheaval altogether analogous: the presence of the jasper south of these mountains, at Mount Houghton—the porphyritic aspect of the trap, are so many indications confirming the proximity of the granite.

The disposition of the beds of trap on the north and east, in the Canadian rivers, at the south at Point Keweenaw, and upon all the American coast, shows the existence of this rock under the greater part of the Lake.

The conglomerates present, in many parts of the country, great puissance, especially at Point Keweenaw, from the Manitou Isle towards Eagle river, and at Isle Royale towards its southern extremity; they are less manifest towards the west, in the Portage and Ontonagon regions.

Their lower beds accompanying the red sandstone offer curious alternations with the upper beds of trap; they have been well shown in the Copper Falls mine, the galleries of which traverse almost all the series.

The layers of conglomerate and sandstone which separate the beds of trap, the alternations presented by the upper part of the trappean formation, and chiefly their immense extent and regularity, seem to indicate that the trap has been produced at the same time as the sedimentary formation, and not posterior to the deposits of these beds.

The sandstone, every where covering the conglomerates and being stratified perfectly in harmony with them, extends from Saut Ste Marie to the State of Wisconsin in three distinct belts, appertaining to the same formation, and broken and elevated by the granite mass of the south and by the trap of Point Keweenaw. It extends certainly under the lake, for it appears at Isle Royale in a position symmetrical with that which it occupies on the south side.

The belt of sandstone farthest south presents on the bank of the lake bluffs by which we can study the medium portion of the formation, which are marked by alternate red and faintly colored beds; on this side the lower part of the formation is concealed by the waters of the lake; the upper part is composed of sandstone, which is almost white and having a calcareous cement.

At the contact of the granite and the amphibolic rocks the beds of sandstone are elevated and dip towards the south.

The second belt of sandstone comprised between the granite and the trap is elevated at the point of contact of these rocks, and presents the form of an immense bottom of a boat.

The beds of sandstone are horizontal in all the middle part of the belt; towards the south, at the contact with the granite they dip toward the north; on the north, at the contact with the trap, they dip towards the south.

It would be a matter of great interest to be able to study in detail the arrangement of the sandstone around the trap; upon almost all the line of separation which extends from Keweenaw Point to Black River the sandstone reposes almost immediately upon the trap, and does not suffer the conglomerates to be perceived but at a shallow depth only in certain places. It is certain, however, that the sandstones should have the same development on this side as on the north, since toward the Algonquin and Douglass Houghton Mines they are symmetrical with the two sides of the trap.

Between these two mines the mountains of trap have a double shape, those which mark the axis of elevation are placed in the slope of the trap zone, whilst everywhere else they approach the southern side. These dispositions suggest the thought that the fracture of the series is oblique and not always perpendicular to the beds: the angle of fracture should be more feeble at Point Keweenaw than in the Ontonagon region; it should be near 90° between the mines above mentioned.

This hypothesis very well explains how the sandstones of the

south can encroach upon the trap and not permit us to perceive the successive (tranches) of the trap, conglomerate, and sandstone, as well as towards the north.

In this zone of sandstone and towards the southern limit, many islets have been recognized, some of trap, others of sandstone presenting beds and seams inclined towards all points of the horizon. They indicate a series of isolated upheavals, as yet imperfectly investigated, where the upheaving rock has not traversed the trap and even has not forced the trap to traverse the sandstone.

West of the Bay of Keweenaw we meet with some strips of magnesian limestone, identical with that which appears between Lakes Superior and Michigan.

They indicate that the limestone extends very far to the south, and that it has been broken and elevated by the upheavals which have given to the country its present appearance.

The belt of sandstone on the north forms all the shore from Eagle River to the foot of the Lake; the beds are elevated towards the south parallel to the beds of the trap, and their angle of inclination gradually diminishes towards the north. They are covered in a great measure by the sands and clays, but we can observe them at different points and establish their identity with those which exist more to the south. The sandstones of Isle Royale dip towards the south reposing upon the conglomerates; they are very evidently a continuation of those observed at Point Keweenaw.

The magnesian limestones, characterized by the fossils which belong to the lower silurian epochs, form a very extended zone west of Saut Ste. Marie; they present themselves also in isolated strips west of Keweenaw Bay. Everywhere it is above the sandstones and reposes upon them in harmonious stratification.

The true origin of the trap appears to me to be very obscure; the American Geologists regard it as a volcanic rock, brought to surface in a perfectly fluid state; but this hypothesis does not explain in a satisfactory manner the disposition and especially immense extent of the trappean beds, which are always and every where strictly parallel to the layers and seams of conglomerate and sandstone.

The arrangement of all the rocks will be more easily explained by admitting that the trap is a metamorphic ferruginous schist.

I cannot now enter upon a discussion of this hypothesis; I should wait until a second voyage to Lake Superior has enabled me to study more in detail the mineralogical characters and the arrangement of all the series.

Whatever, however, may be the origin of the trap, it is evident that it is produced in horizontal beds both before and during the formation of the conglomerates, upon which are deposited the sandstones, and later, the magnesian limestones.

The whole of the rocks, trap, conglomerate, sandstone, and limestone, have covered an immense basin, of which only a part is occupied by Lake Superior.

The granite has ruptured, upheaved and even traversed all the series, and, during the overthrow produced by its appearance at the surface, the limestone has been almost completely raised.

The direction of the two granite chains of the north and south, that of the beds and seams of Isle Royale, the direction which we can ascribe to the zone of trap of Point Keweenaw, neglecting its sinuosities, are E. 25° N. to W. 25° S.

We must admit from the fossils of the magnesian limestone, that the series observed at Lake Superior belong to the lower silurian period. The upheaval must have been made at the period when the limestone was deposited under the waters.

SECTION III.—THE ALLUVIUM.

We meet in all the north of America with rocks, polished, striated, or furrowed, in a certain direction, deposits of sand, clay, gravel, pebbles and blocks of all dimensions, transported from north to south, the explanation of which has produced numerous discussions between the most eminent geologists.

In America and in the north of Europe, the facts which have been observed are almost identical; the materials transported appear to have moved in the same direction; it is on the whole, from north to south, but presents many local deviations, according to the obstacles which high mountains have opposed to the movement.

At Lake Superior these phenomena are evidently posterior to the deposits of native copper, with which they have no relation; their investigation is highly interesting, upon which however I can bestow only a few moments. I shall state only the facts observed in the country, without entering upon the discussion of the hypothesis advanced in order to explain them.

Polished, striated and furrowed rocks. The furrows traced upon the rocks, the form of which is rounded on the north side, belong certainly to the commencement of the erratic period, for at many points we meet the striated under the most ancient alluvium; they are chiefly to be seen at Isle Royale and at the Eastern extremity of Point Keweenaw in consequence of the absence of the alluvium.

At Isle Royale the promontories which advance towards the north-east are rounded and striated on two sides; all the side exposed to the north presents alike the striated appearance, and the rocks are every where rounded and polished. The western extremity of the island does not present any indications of this nature, but we find them perhaps less developed upon the south side. The conglomerate itself is furrowed like the trap, but the striated appearance is less distinct; this should be ascribed to the

fact that the conglomerate is not so hard a rock, and the atmospheric agents have more easily produced a decomposition of its surface.

The direction of the striæ appears to be in the whole extent of Isle Royale N. 50°, E. and S. 50° W.

At Point Keweenaw the alluvium has not been determined in all the eastern part, but the polished and striated rocks are very apparent throughout the trap zone; their general direction is N. 20° E. We do not distinguish them upon the conglomerates and sandstones for reasons I have indicated above, in consequence of the slow decomposition of the surface by atmospheric agents. At the west, in the Portage and Ontonagon regions they are almost concealed by the alluvium.

On the granite mass of Carp river the borders of the lake and all the slopes of the mountains exposed to the north, present striæ directed on the whole to the north-east and south-west. The directions observed are very different, extending from N. to S. even to N. 65° E., from that which appears to be the normal erratic direction even to that of the chain of the granite mountains.

The explorations made in this region are not sufficiently numerous to enable us to establish the relation which should exist between the direction of the striæ and the height and form of the mountains on which they are observed.

Pebbles, clay, sand, gravel and boulders. The deposits which I have designated at present under the name of alluvium, comprise very diverse materials, which present very often an appearance of horizontal stratification. This alluvium is most developed; upon the south side of the lake from Saut Ste. Marie even towards Chocolate river, on all the belts of sandstone north and south of the trap, they fill the bottom of the trap valleys in all the Ontonagon region, at the west they have been noted beyond Fond du Lac. On the south they extend to the east prairies of Wisconsin and Illinois.

Boulders, of all dimensions, rounded and composed of hard rock, granite, hornblende, trap and even native copper and fragments of veins, some polished, others striated, have been found in the sand, clay, gravel and deposits of pebbles. They are found, likewise, isolated, upon many high mountains, 300 metres above the level of the Lake.

The blocks have consequently been deposited during the whole of the erratic period; they have been transported from the north toward the south; for at every point where they are found they are composed of rocks which exist only at the north. Those of Isle Royale, Point Keweenaw and Ontonagon come originally from rocks on the southern side of the Lake; the blocks of the south and south-west, which form a long chain in Wisconsin and Iowa, come from the granite and metamorphic mass which extends south of the metalliferous region.

The best proof of their transportation from north to south is the existence of blocks of iron ore south of the region of Carp river, whilst none of that nature are found more to the north.

In studying the arrangement of the alluvium we can recognize a probable succession in the deposits of pebbles, clay, sand and gravel.

The pebbles mixed with sand and clay are the base of the formation; they do not appear at the surface but at the borders of the lake, in the two zones of sandstone, around the Pictured Rocks and the Portage. They are not at a great height above the level of the lake; the materials which compose them seem to have come from the adjacent mountains, and not to have been transported a great distance.

The clays very, regularly stratified, but containing likewise pebbles and blocks of considerable dimensions, repose upon the preceding deposit, or upon the rocks themselves, where the deposit is wanting. They have been found at the base of the alluvium near Saut Ste. Marie, and especially in the Ontonagon. In that part of the lake they fill the valleys of the zone of trap, and appear to have come from the decomposition of the trap rock. They present themselves likewise, but more mixed with quartzose sand, north of that zone in the valleys of the conglomerate and feldspathie sandstone. The clays accompanying the sand and gravel are very abundant in the belt of the sandstone south of the trap. It is impossible to tell the real thickness of the clay; it does not appear to exceed 15 to 20 metres.

The sand and gravel accompanying the pebbles, sometimes colored red, sometimes almost white, presents itself above the clay at the extremity of the river of the Saut, at Grand-Sable; in all the other parts of the lake it is difficult to distinguish whether the sands are more recent than the clay, or whether the two deposits are cotemporaneous. They exist for a thickness of 20 or 30 metres over the three zones of which I have spoken at the commencement of this chapter, forming gentle slopes towards the lake, presenting terraces in which we can see a proof of the successive elevations of the series, or filling the narrow valleys, bounded by the mountains of sandstone..

It is important to remark that upon the south shore east of Saut Ste. Marie and upon the zone of sandstone extending north of the trap, the sands are in general almost white, and their color has an evident relation to that of the beds of sandstone upon which they repose.

We can investigate the changes of color by proceeding from the village of Ontonagon to the Toltec mine situated more than 25 kilometres towards the south; we see the alluvium of pebbles and sand colored more and more and becoming more clayey as we approach the conglomerates and trap.

This observation leads us to regard the sand and gravel as

preceding the local disintegration of the surrounding rocks, at least in a great part, and consequently to admit that the two deposits of sand and clay are almost cotemporaneous, produced by the same cause, and that they have not been transported a great distance.

Irregular beds of gravel and pebbles cover the sands at a small number of places; they are not well developed except on the south shore of the Lake, at Grand-Sable and on the west side of St. Mary's river. Their thickness does not exceed 4 to 5 inches, and their arrangement in irregularly stratified beds appears to indicate a less tranquil period than that of the clay and sand.

The terraces of Lake Superior are well characterized at different points, as Grand-Sable, and on the south coast, and east and west on the Canadian shore. Their aspect and dimensions are not the same both north and south, and each terrace has a particular arrangement.

They present a succession of slopes, retreating one above the other, extending a distance of many kilometres in gradually approaching each other.

It is proper to regard each of these terraces as indicating the level of the lake at a recent period, but then it is necessary to admit that the terrace has been diversely elevated at different points of the lake at successive epochs. If the elevation had been general, we should find in all the terraces that correspondence of height and that continuity which is now wanting.

The irregular and momentaneous variations of the level of the lake which we now observe, especially upon the shores of the great lakes, can be explained by movements of the ground which has successively sunk and risen. By this hypothesis we can see in the actual variations the continuation, on a small scale, of the phenomena which have produced the terraces.

We can likewise conjecture that the absence of alluvium at the extremity of Point Keweenaw and Isle Royale could proceed from the denudation produced by a momentary upheaval beneath the level of the lake. We can likewise indicate at Point Keweenaw the Portage lake as the axis of rotation.

We should not confound with the ancient alluvium the deposits of sand which the rivers bring to the borders of the lake, and which form at their mouths more or less developed bars. We can study them at Eagle river, and especially at Ontonagon; in that region the coast is very low and formed of sand and gravel, upon which they are deposited even to a great distance from the shore.

The discussion of the hypothesis to explain the striæ and boulders and ancient alluvium, would lead me beyond the limits of this essay. That question is too important for me to attempt after only a single visit thither, in which my attention was directed principally to the deposits of copper. I hope to discuss it in

a future work after having visited again these distant regions. I shall seek to establish at the same time, in a most precise manner, the relations which exist between the trap and conglomerate; for these relations only can establish the point whether the trap of Lake Superior has really been in perfect fusion, or if it should be regarded as a metamorphic rock, representing the graywacke of Europe.

(To be Continued.)

ART. VI.—THE COPPER VEINS OF THE SOUTH.—By OSCAR M. LIEBER, Assistant Geologist to Alabama.

WHAT are true veins? is a question, the answer to which is of the utmost importance to the practical geologist or scientific miner, and yet we find it very differently and frequently somewhat unphilosophically answered. Some define veins as bodies of rock, whose dip or strike is at an angle with that of the strata of the circumjacent rocks, so that the same bed may, if we adhere to this definition, be a vein at one point and an ordinary stratified bed in another. I believe it was Werner, however, who already observed that indication of a secondary formation, of an origin subsequent to that of the neighboring rocks, is a necessary characteristic of veins. It matters little whether or not the mere external features of strike and dip are conformable to those of the beds through which they pass; and, indeed, it would be difficult to point out an instance where, in depth, the vein does not gradually assume the dip of the rocks of the country. An explanation of this phenomenon is not difficult, when we reflect that veins are simply crevices, subsequently filled. Whatever may have been the originating cause of these fissures—elevation of the rocks or gradual contraction of our globe while cooling, and consequent breaking up of its crust—it is very easily conceivable, that the surfaces of the beds, being the points of less intimate union, would be the ones most liable to rupture, and that, with but few local exceptions, the fissures would follow their course.

We find, as a general rule, that near the surface the veins are irregular or split up into a number of smaller ones, which the miner terms "feeders" or "leaders." We have here, an instance, but on a grand scale, of that which we find in the rupture of any earthen vessel. On the outside the crack is irregular, and small pieces are entirely severed from the main body.

In some instances it may be difficult to determine by superficial examination whether a bed is a vein or not, where no peculiar orographic features are discernible. Nothing will then

suffice but an investigation of the oryctognostic characteristics made at a depth where their peculiarities are sufficiently developed, and where the nature of the bed may be ascertained from the mineral composition or the orographic distribution of these ingredients.

An interesting case, where the writer was at first inclined to believe a bed, of regularly stratified origin only, existed, is to be found in Talladega county, Alabama, where they are at present making experimental investigations for copper. A more careful inspection, however, proved that this was really a true vein. In the first place we have the repetition of the solid quartz on both sides, an instance of that singular parallel disposition of the ingredients of veins, which has led Cotta to found his famous theory explaining the origin and mode of introduction of the minerals now filling the vein crevices. In the second place we find a singular asbestiform variety of quartz, which consists of long imperfect acicular crystals, standing at right angles to the dip of the rocks, and which would therefore also induce us to believe that it must have been deposited in a crevice, and hence subsequent to the formation of the adjoining rocks.

Another remarkable instance of this group of veins is to be found at the Waltruss mine, in Polk county, Georgia, where of one lode no outcrop was observable, and where it was found in sinking a shaft to strike an entirely different vein, which is below this, and will, in all probability, join the main body. The latter is at present fifteen feet thick, though mixed with slate on the hanging wall. The foot wall is quartz, the upper part of the vein iron pyrites, while at a depth of about thirty-five feet the copper first makes its appearance in noticeable quantity, entering in irregular masses. It is very probable that at a comparatively insignificant depth very valuable copper ore will be reached, since already such unexpectedly fine results have crowned their desultory operations.

I have not myself visited the mines of Ducktown, in Tennessee, as yet; but all descriptions seem to point to a great similarity of their characteristic features to those of the Georgian mine just described, although there in most cases they find a black cupriferous mineral, consisting of impure black oxide and sulphate, between the gossan which forms the iron hat and the undecomposed sulphurets of iron and copper.

The gossan is a silico-ferriferous mineral, which presents very distinct appearances in different localities. Thus at one time we find it cellular, at another compact, at a third lamellar. Sometimes it is friable, sometimes solid. In some places it seems to be arenaceous, at others it consists of a cemented breccia of the slate and quartz, the cement being impure peroxide of iron. In many cases this compound rock is doubtless of later origin, a secondary formation, in which the iron cemented together broken pieces of

the "country" rocks. At first I was inclined to believe that this was the case with all of it, though lately it has become very evident to me that much of it belongs to what German miners term "Gaug-Trumm," (from *trümmer*, ruins, and *gaug*, vein) and which we also find far below the surface in the veins. Meeting with so much slate too at the Waltrup mine, mixed with the copper and iron pyrites, we perceive also another source whence these imbedded irregular or breccia-like pieces of schistose rock may have been derived; so that, indeed, in many instances they may still occupy their original position, being merely surrounded by the hydrated peroxide of iron, derived from the pyrites. "Gossan" is a term, referring only to the oryctognostic features of the mineral, although it has latterly been used as synonymous to the German word "*Eisen Hat*," iron hat; a term descriptive of the orographic character. Sometimes the outcrop of such veins is a cellular quartz, itself of a pure white, but colored superficially by peroxide of iron. Mr. Dury of Alabama, who has devoted much time to the study of this group of veins, is of opinion that the shape of these cells may afford us some light in judging of the character of the veins in depth. This view is based upon the well-ascertained fact that a mineral, which crystallizes according to various systems, as for instance sulphuret of iron (rectangular and rhomboidal), will, as a rule, retain that form throughout in the same vein. Only where the iron pyrites crystallized differently from the copper ore would it be possible to find a guide in this. If both crystallize in octahedrons we shall not be able to distinguish their impressions, but if the iron pyrites is of the rhomboidal variety, and we find among the cavities not only rhomboidal cells, but also octahedral ones, then, according to Mr. Dury, we may expect to find copper. These views are very sound ones; and we but need greater experience to ascertain whether they are true in all cases; since he has communicated his theory to me, I have, where it was possible to test its correctness, found it to be true.

The same gentleman, who has examined these veins from Virginia down to their south-western terminus, believes that they are confined to the intermediate space between the Alleghanies and Blue Ridge, and that the extensive group of veins described by me in the "New York Mining Magazine" for October, 1855, and characterized by gold, lead and copper, with a highly quartzose gangue, never encroaches upon the region occupied by the other group. As distinct names will be of importance, as rendering tedious descriptions unnecessary, I would suggest that we term the former *the Ducktown group*, from the well known mines of Tennessee, where they were first opened; the latter *the Carolina group*, since in the two States of this name it seems to be most perfectly developed.

Let us now review what appear to be the chief characteristics

of this Ducktown group as far as our present very limited knowledge of them permits us to decide.

First is the slate or other country rock, then the outcrop of iron ore or gossan, sometimes here, from subsequent action, more or less stratified. At one point the gossan is certainly in place, and the vein "has formed;" i. e., its wall is distinctly discernible. Farther down is black oxide and sulphate of copper, greatly adulterated by silica, &c.; still farther is the undecomposed portion of the vein, and consists of a solid mass of sulphurets of iron (in Ducktown arsenical pyrites?) and copper mixed with quartz, the copper increasing in quantity downwards. As footwall we find a solid quartz with some sulphurets. Nearer the surface the rocks are decomposed and the stratification indistinct by surface action.

Now it is very evident that at one time the whole of the metallic portions of this vein were pyrites, and that atmospheric action produced sulphates and oxides. The iron, in the shape of sulphate, was in part leached out and gave rise to the stratified deposit in many instances worked for iron. A portion of the sulphate and black oxide of copper collected lower down and formed, as it were, *a bed in the vein*, though deposited irregularly and frequently only on the footwall. This is the ore which was first worked at the Tennessee mines. When the gossan is in place (though it is not found in all instances), we find the vein in its original state, the copper increasing in quantity in depth, and those examinations which I have been able to make latterly, have certainly induced me to believe that there will yet be discovered vast storehouses of nature, which will at a future, though I trust not distant day, do much towards furnishing the world with the necessary amount of this valuable metal.

Although, strictly speaking, the only true ore of these mines, or at least the only one whose persistence we may depend upon, is the sulphuret of copper, still we meet with other cupriferous minerals also. The sulphate and impure black oxide have already been mentioned. The red oxide occurs in some instances, as at Gamble's mine in Polk County, Georgia, while native copper, a galvanic precipitation from the sulphate and hence of secondary origin, is met with for instance in the mines of Ducktown, and at M'Gee's in Talladega county, Alabama. Carbonate of copper of the green variety has formed in many instances near the surface or on exposed specimens of the black ore, and the hydrated silicate of copper or *dioptase* of the Germans is found also, though rarely. With the exception of the latter, these minerals are all the direct or indirect products of the decomposition of the pyrites and of but little practical importance.

Undeveloped as these treasures still for the most part remain, we see already that the Blue Ridge is, probably, but the dividing line between two groups of veins seemingly almost unparalleled in

extent, and that, in all probability, our Southern States may congratulate themselves upon being most munificently provided with

> "Plenty of the rarer, milder ore
> Of which the early Roman forged his sword,
> And Greece, undying, her creative chisel."

Art. VII.—FOSSILIFEROUS FORMS IN EASTERN MASSACHUSETTS.*

Prof. William B. Rogers exhibited to the Society several specimens of rock containing casts of portions of a large Trilobite lately obtained by him from a locality on the north edge of Braintree, about ten miles south of Boston. He adverted to the great interest of this discovery, as furnishing the first clear evidence yet obtained as to the geological age of any of the extensive series of altered rocks which occupy a large part of Eastern Massachusetts and the neighboring States.

Hitherto geologists have not been aware of the existence of any fossil forms in these strata, as none are referred to in the Geological Report of Prof. Hitchcock, or in any of the subsequent publications relating to the rocks of this region. The present discovery, therefore, will be a matter of surprise as well as gratification to those who have given attention to this obscure and hitherto unproductive portion of our geology.

It is true, that in view of the lithological characters of these altered rocks, and their relation in strike and position to the carboniferous strata adjoining them towards the S. W. in the contiguous parts of Massachusetts and Rhode Island, they have of late been considered as probably belonging to parts of the Paleozoic series inferior to the Coal Measures, and including portions of the Devonian and Silurian systems. But the want of any positive evidence derived from fossils has, until now, left us without a clue to the actual Paleozoic age of any part of the group, and has indeed given a character almost purely conjectural to speculations in regard to the epoch of the group at large.

In respect to the zoological relations of the Braintree Trilobite, Prof. Rogers remarked that from the imperfect examination he had as yet given these fragmentary specimens, he was disposed to consider it as closely allied to the forms of Paradoxides described by Green in his monograph, on North American Trilobites. Of the two species described by Green, viz., P. Harland and P. Boltoni, only the latter has been recognized by Prof.

* Boston Society.—Nat. History.

Hall among our Appalachian fossils. This, under the generic head of Platynotus, and more recently of Lichas, he describes as a characteristic form of the Niagara group. Leaving the precise affinities of our fossil for future examination; there can be no hesitation from its general features, in referring it and the including strata to a date among the more ancient of the Paleozoic formations.

The rock in which these fossils occur is a rather fine-grained bluish gray siliceous slate or slaty sandstone, forming part of a narrow belt of siliceous and argillaceous slates and grits ranging along the northern edge of Braintree. The fossiliferous layers are exposed in a quarry, which has been wrought for several years past to obtain ballasting material for some of the wharves in Boston, within which no doubt many of these fossils might be found among the piles of stone. The fossil casts occur not only on the parting surfaces of the strata, which are covered by a somewhat argillaceous and ochreous coating, but also in the interior of the mass, whence, however, they are less readily separated for examination.

It appears that the proprietor of the quarry, Mr. E. Hayward, and his family, have for some time been familiar with the occurrence of these so-called images in the rock, without a suspicion of their having any scientific value. But it is to the kindness of Peter Wainwright, Esq., a member of this Society, who resides in the neighborhood, that Prof. Rogers has been indebted for the first suggestion which led to the investigation of this unique and most interesting locality.

The range or strike of the fossiliferous belt is about N. 70 E., and the dip in the quarry N. 20 W., at an angle of about 45°. Adjoining it, on the N. W. side, are exposures of a more argillaceous and indurated slate, greatly broken up by joints and irregular cleavage planes, and at a short distance further on, in the same direction, these altered sediments give place to the granitoid and sienitic masses so extensively quarried in the town of Quincy. In crossing the strata towards the South, we meet with slaty and gritty rocks, becoming more and more indurated as we proceed, which passing into beds of a semi-crystalline character, are quickly followed by another range of sienite. Thus the fossiliferous belt is actually included, in this part of its range at least, between large masses of igneous rock, and it is not a little surprising that under conditions so favorable to metamorphic action, the fossil impressions should have been so well preserved.

This discovery of well-marked fossils among the rocks of Eastern Massachusetts, where hitherto their existence could scarcely have been suspected, may well lead us to hope that careful research in other parts of this region of altered sediments will bring to light fossil organisms not less interesting in their scientific bearings than the Braintree Trilobite.

Dr. Jackson observed that Mr. Cyrus Alger had a fossil, apparently identical with these and imbedded in a similar rock, which was obtained at the sale of the old Columbian Museum in this city. Its origin was unknown.

Dr. Hayes remarked that it was with the deepest interest that he had listened to the announcement of the discovery made by Prof. Rogers. The new and important facts now made known by that gentleman, throw a clear light on what was obscure, and enable us to generalize many isolated observations made in this vicinity, which without them had no scientific basis: and it must be the wish of all, that Prof. Rogers would give his attention further to this subject.

Incidentally connected with the discovery of Prof. Rogers, are some observations he had made while pursuing a research on the origin of the saline matter found in the waters which traverse the rocks and drift of this part of the State. These rocks, in the simplest form of expression, are broken-down granite, the resulting sand being re-cemented to form aggregates, to which we mineralogically apply different names. It is to the material of this cement that he would call attention, as numerous experiments have shown that it is the source from which the waters take their saline matters when percolating these rocks.

Not only are the chlorides of the metals forming alkalies when oxidized present often, but we find salts of lime, which did not probably pre-exist in the sand, or original rock.

The sulphate, phosphate, carbonate and crenate of lime are thus found, and when the aggregate reposes on other rocks, these salts are imparted to them, in considerable amount.

Thus the argillite of Charlestown is an example of quite a collection of lime salts, associated with the proto-persilicate of iron. In other parts of New England, where the argillite passes into roofing slate, and again where the metamorphic changes have occurred, we find either these salts, or the minerals into which they have passed. Now these lime salts are foreign matters of interest, for they most commonly claim an organic origin, and associated as they generally are with iron salts, which have retained some portion of protoxide, in consequence of the presence of organic matter, or carbon itself, they afford indicative evidence of the presence of organic matter earlier in geological age than the organized forms which abound in other rocks.

COAL FORMATION OF DEEP RIVER.

Dr. Charles T. Jackson read the following paper on the Coal formation of Deep River, N. C.:

During the month of May last, I had an opportunity of re-examining the coal fields on Deep River, N. C., and of tracing the outcrop of the coal bed some miles farther to the south-west-

ward, and across Deep River from Murchison's to Forshee and Street's plantations.

I had also the satisfaction of descending into the shaft sunk in the plain of Egypt, where two years since I directed borings to be made by which the occurrence of coal beneath that plantation was discovered, and its extent under the table lands demonstrated.

This shaft, sunk under the immediate direction of Mr. Wm. McLean, is admirably constructed, is 8 feet by 15 square, and penetrates to the depth of 462 feet, where it traverses the coals.

At the bottom of this shaft I measured the following section:

Coal,	4	feet
Black band iron ore,	16	inches
Coal,	22	inches
Fine clay,	6	inches
Coal,	7	inches
Fine clay and shale at bottom.		

The strata and coal beds dip from 16 to 20° S., 10° W. The aggregate thickness of the coal that can be taken out together in the chambers is 5 feet 11 inches in thickness.

These coals are quite free from sulphur, and are highly esteemed by the Superintendent of Brooklyn (New York) Gas Works as good gas-making coals.

They are also particularly valuable in the forges, since they make a perfect hollow fire by caking readily. They also will serve for steam engine and other fuel.

On chemical examination this coal was found to yield, per cent.,

Fixed carbon,	63.6
Illuminating gas,	34.8
Red brown ashes,	1.6
	100.0

When converted into coke it was found to produce 65 2-10 per cent. of good solid coke.

The black band iron ore is too sulphurous to admit of its being converted into good iron, it retaining 0.89 per cent. of sulphur even after thorough roasting. It yielded on analysis, per cent.,

Coal,	31.30
Peroxide of iron,	47.50
Carbonic acid and mixture,	8.81
Sulphur,	3.39
Silicious matter,	9.00

The oxide of iron was originally a protoxide in ore, but was separated as a peroxide.

At one time the geological age of the Deep River coal formation was a subject of dispute among geologists, some maintain-

ing that it belonged to the New Red, and others to the Oölitic or Lias group.

Through the researches of Prof. Emmons, State Geologist to North Carolina, this question is likely to be finally settled, and it appears from his geological map, a copy of which he kindly gave me, and from his fossils which I have inspected, that the lower portion of this formation is triassic or of the New Red Sandstone group and the upper Liassic.

Among the fossils discovered in the Deep River coal-bearing rocks, are numerous teeth and bones of saurian reptiles, coprolites of saurians and of fishes, and an abundance of scales of ganoid fishes resembling captopterus of Redfield.

Several species of Zamias, both the trunks and leaves, are also found. These will all be described in Prof. Emmons's report, and will be represented by wood-cuts. I understand that this annual report is now in press at Raleigh, N. C.

CHEMICAL ANALYSIS OF A VARIETY OF AGALMATOLITE, BY C. T. JACKSON.

A remarkable rock, supposed until now to be soapstone or talcose rock, was discovered a few years since on the borders of the Deep River coal field, and was quarried as soapstone, but found unsuitable for lining stoves and furnaces, on account of its ready exfoliation when heated.

Lately other uses have been found for this beautiful material, for when ground it is a delicate white satin-like substance, and is similar to China clay. It is ground and bolted, and sold in New York at $40 per ton. I suppose it is employed to mix with white lead, and it is said to be used also for the adulteration of fancy soaps, and also for glazing or satining wall paper.

By chemical analysis I find this rock is composed of, in 100 grains,

Silica,	75.00
Alumina,	18.75
Potash,	2.00
Water,	3.50
Traces only of oxide of iron,	
	99.25

It is therefore Agalmatolite.

Remarks upon the Deep River coal formation were also made by Prof. Rogers.

Dr. Hayes asked Dr. Jackson what chemical evidence there was that the North Carolina or Deep River coal was a gas coal.

Dr. Jackson replied that his experiments were made in the usual manner, in covered platinum crucibles (which represent very perfectly the gas retorts), and that he found the North Carolina coal to produce 34 8-10 per cent. of coal gas, which burned

with a brilliant yellow and highly illuminating flame, without smoke, and did not give any sulphurous acid, or other disagreeable products; while the coke resulting from torrefraction of the coal was found to be of superior quality, giving less than two per cent. of ashes when burned. Practical trials made with this coal at the Brooklyn (New York) Gas Works, had fully proved its excellence as a gas coal.

To this Dr. Hayes added, that an experiment thus made hardly demonstrated, in his opinion, that the coal was a gas coal. The amount of volatile matter given off from any coal, varies with the rapidity or slowness of heating it, and may be made up of vapor of water formed from the constituents of the coal, and heavy vapors producing coal tar—together burning with a bright flame, from a coal wholly unfit for making gas. The coals of our Western States and those of Scotland, offer fine illustrations of the error which might be committed in an experiment of this kind; some affording a large volume of rich gas under a small percentage of volatile matter, and others with a large amount of volatile matter, burning brilliantly, but producing very little gas. The distinction between gas coal and bituminous coal can be learned by more complete processes only, and his own experience on this coal, soon after it attracted public notice, and with strong hopes that it would prove a gas coal, did not lead to such a conclusion.

JOURNAL OF MINING LAWS AND REGULATIONS.

IMPORTANT CASE—RIGHTS OF WATER COMPANIES.

In the District Court of Placer County, California, Judge Howell presiding, a case has just been tried which involves a question of the utmost importance to the mining interest of the State.

The facts in the case, as developed at the trial, are thus set forth :—

The Bear River and Auburn Water and Mining Co., located in 1851 a canal for the purpose of conveying water into the dry diggings of the lower portion of this county. For this purpose they constructed a dam across Bear River, some twenty miles north of this place. At the time of locating their canal the water of Bear River was pure, and ample in quantity to fill the canal. Since the construction of this work various other companies have located dams and canals above, for the same purpose, returning the water into the river above the dam of the Bear River Company.

The consequence has been a material diminution of the quantity of water by absorption and evaporation as well as a serious deterioration in its quality. The soil of the mining regions through which the water is passed by the subsequent locators, is of such a nature, that the water reaches the dam of the Bear River Company almost unfit for use; and the immense amount of sediment brought with it chokes their works, causing great expense in keeping their ditch and flumes of sufficient capacity.

Among the subsequent locators is the Little York Company, the termination of whose canal is some fifteen miles above the dam of the Bear River Company. The Bear River Company have sued the Little York Company for damages, and for a perpetual injunction against further use and injury of the waters of Bear River. The facts established on the trial are substantially as we have stated them, and the Court is called upon to decide as to the respective rights of the parties. The testimony and argument occupied some three or four days, and the jury were put in possession of every material fact at issue. They returned into court with a special verdict, to the effect that the Bear River Company had suffered damage to the extent of $5000—that the damage had resulted from the use of the water of Bear River by the Little York Company, but that the latter company had used the water without useless waste or extravagance, for the usual purpose and in the usual manner. Upon this finding it is left for the Court to decide as to the right of the Little York Company to use the water of Bear River at all. This is the question at issue, and it is impossible to conceive one of greater moment to the whole community.

If judgment is rendered in favor of the Bear River Company, all that valuable mining district lying between their dam and the summit of the Sierra Nevada must be abandoned, the capital invested in mining and water companies will be lost, and the thousands of miners of that district, must remove to other localities not subject to the same disability.

It is not alone the loss and inconvenience to be suffered by those parties that is to be considered in the event of a judgment for the plaintiffs in this action. A principle will be established, the inevitable result of which will be the immediate institution of hundreds upon hundreds of similar suits throughout the whole mining portions of the State, and which will apply as well in cases where water is diverted for other than mining purposes. The doctrine will be declared and become the law of the land, that the first occupant or locator upon the banks of a stream at its mouth has an indefeasible, exclusive, perpetual right to the waters of that stream in its original volume and purity. The bare fact of his prior occupancy will operate as a perpetual injunction against any future location upon its entire length, if such subsequent location tends to the injury of the first locator. In other words, the first locator at the mouth of a stream becomes its proprietor from its source in the mountain springs to its termination.

Water is the great agent by which alone the staple resources of this State can be developed. The supply is limited, and it is, therefore, of inestimable value. Every principle established regulating its disposition is of immense interest to the whole people. Every mountain stream, brook, and rivulet has been diverted again and again, from its natural bed, until the whole surface of the country has become a perfect net-work of canals and ditches. Science has been brought into requisition, enormous sums have been invested, and labor beyond estimation has been expended in the mighty enterprises for the development of the mineral wealth of the land.

An edict that shall go forth declaring that so many of these great and necessary works as tend to the injury of the first locator upon each stream shall be abandoned, will work a disaster, the extent of which no man can compute. The experience of each passing year has shown that the greatest mineral wealth lies high up in the mountains. Year after year the gold hunter has penetrated farther and higher up toward the summit; and year after year the placers among the low foot-hills have been gradually depopulated. In a few years these placers will be totally abandoned. They are of a character that when once worked they are useless for ever. In the mountains the character of mining is such that those mines are considered inexhaustible.

The first canals which were located on the streams were intended to wash the placers of the foot-hills. In order to render the inexhaustible treasures of the mountains available, it is impossible to avoid damages to canals. The use of the water in the mountains will inevitably diminish the quantity of

water, and in a measure depreciate its quality. If our courts declare that this diminution and depreciation is wrong, and forbid it by perpetual injunction, they then declare that the mining in California shall be confined solely to the placers of the foot-hills, and that the boundless wealth of the mountains shall lie for ever hid from the eye of man.

There is room for argument on the other side of the question, and these canal companies have, undoubtedly, many rights which it would be hard to deprive them of. But we are strongly of opinion that the best interests and prosperity of the State, and a principle of broad natural justice, is adverse to the position assumed by the plaintiffs in this action.

The argument upon this special verdict was, by argument of counsel, set for a future day, and to take place at Sacramento.

COMMERCIAL ASPECT OF THE MINING INTEREST.

MINING STOCK IN BOSTON.

Boston, October 29, 1856.

The aspect of the Mining Share Market has not materially changed from last month. Stocks of the reliable kind being in good request at improving prices; and we feel sure such are gradually gaining strength with the investing public. It is not surprising that so successful a property as the *Minnesota* or *Pittsburg* should attract attention from parties who have capital to invest, paying as they do a large percentage on even the present market value. *Minnesota* has sold up to $102, which is equal to $680 for a share before the number was increased from 3,000 to 20,000 shares. It is now certain that this Company will pay $10 per share from the profits of the present year's product; and it is highly probable that $15 will be divided. The copper produced for this year will vary little from 1,800 tons; and from present appearances is more likely to exceed than fall short of that amount. The product of 1855 was 1,434 tons. *Pittsburg* sells at 231 with 6,000 shares, and its future prospects are highly flattering—the dividend for six months ending in August last, being $20 per share, which amount, it is thought, can be kept up for the future; at any rate $15 for each six months can be looked for with certainty. Below will be found a synopsis of the annual report of this Company, which shows the basis for future dividends. This Company has always pursued the policy of making *semi-annual* dividends at regular stated times (February and August), which is of no little importance to the permanence of thestock. We are surprised that the *Minnesota Company* have not adopted a similar course before this; for it certainly would be to their advantage, and is desired by the stockholders. We, of course, can speak positively only for the shareholders in this immediate vicinity (say 3,000 to 4000 shares), but have little doubt that the measure would be a popular one with all.

Rockland has sold at 30 within a week, and that price is now bid "seller thirty" days, with only a few shares offered at 32. This mine has been even more successful thus far than its friends anticipated, and is now raising over 80 tons of copper per month. It is following steadily in the track of the Minnesota, of which it is an off-shoot, and has the same vein.

Isle Royale has fallen to $8 per share in consequence of general disappointment at the reduced product of the year At first, 300 tons was the amount sure to be obtained, then 275, and afterwards settled down to 260. As a *finale*, we now have the pleasing (?) information that by the mistake of some blunderhead, 30 tons were returned *twice*, and consequently only 230 tons will be

realized for the year ending in November, 1856. With this result, however, the Mine will pay expenses, and have, perhaps, $30,000 of available assets to carry on the work for the winter with.

Superior is in demand at $8, and at present the market is quite clear of stock.

Flint Steel River dull at $4\frac{1}{4}$ to $4\frac{3}{4}$, without transactions here for some months.

Pewabic has declined again from 5 to $4\frac{1}{2}$, but finds strong buyers at that figure.

Toltec has almost faded out of sight for the present, at least; and it is probable that work will soon be stopped for the winter.

Copper Falls has fallen to $$81\frac{1}{2}$ per share, in expectation of an assessment of probably $1 per share, shortly.

National has not sold lately; the last public transaction being at 25. The best offer now is 20, though the shares cannot be had at that rate at present. We have received the report of this Company (the first printed one we believe), which gives a full statement of its "past history, present condition and future prospects." The whole territory comprises $1540\frac{864}{100}$ acres of mineral and agricultural land in the Ontonagon District, adjoining the Minnesota Mine, the vein of which runs through a portion of the National property, and its characteristics are exactly the same, "except that it does not yet carry such heavy masses of copper as are so frequently met with upon that highly favorable location."

From the commencement of the Company's operations

	Assessments.	Sales of Copper.	Total.
To June 28, 1854	$39,658	$18,618,89	$58,276,89
From June 28, 1854, to July 2, 1855	49,563	24,246,91	78,809,91
From July 2, 1855, to July 1, 1856	20,639	11,625,85	82,264,85
	$109,860	$49,419,15	$159,351,15

No assessment has been called for since April, 1856; but in the mean time (to October 1) shipments of mineral have been made and received as follows: 122 lbs. of barrel work, weighing 96,024 lbs., and 156 masses, weighing 91,117 lbs., in all 187,141 lbs. ($93\frac{1}{2}$ tons), which has been mostly smelted, and found to yield, exclusive of the slags, 76 per ct. of pure copper. These shipments represent the product of the Mine since the close of Navigation last year (November, 1885), and are *not* included in the foregoing periodical statement. The average number of hands of all descriptions employed at the Mine has been, in 1853, 34; 1854, 90; 1855, 67; and to July 1, 1856, 60. At the present time the force employed consists of 46 miners, 18 laborers in the mine, 14 surface hands, agent and mine captain, in all 80 men. The improvements at the Mine include 15 good dwelling-houses, office, warehouse, barn, carpenter-shop, and smith-shop. Twenty-five acres of land have been cleared, 12 of which are under cultivation. The Directors say that "no doubt whatever is entertained (by us) that the National Mine, as at present worked, and independent of that portion of their territory in dispute with the *Minnesota Company* (viz.: 80 rods in the course of the veins), will become a paying Mine when it has been opened in depth, to correspond with the level attained at the Minnesota."

The report of the Agent shall be given in our next.

COALS AND COLLIERIES.

ANTHRACITE COAL TRADE IN 1856.

Shipments by Reading R. R. to Oct. 3d,	1,707,403 16	tons.
" Schuylkill Canal,	842,525 16	"
	2,549,929 12	"
Same time last year,	2,690,978 12	"
Decrease so far,	141,049 00	"

Delaware and Hudson Co.'s Coal Trade.

To Sept. 26th,	374,174	tons.
To same time last year,	440,123	"
Decrease so far,	65,949	"

Pennsylvania Coal Co.'s Coal Trade.

To Sept. 26th,	422,014	tons.
To same time last year,	373,014	"
Increase so far,	49,000	"

Scranton Coal Trade for August.

Del. Lack and R. R. Co.	185,548 14

LEHIGH COAL TRADE FOR 1856, BY CANAL.

To September 26th.

Summit Mines,	221,346 08	tons.
Room Run Mines,	48,423 07	"
East Lehigh Mines,	24,078 18	"
A. Lathrop's Pea Coal,	1,815 09	"
Spring Mountain Mines,	73,921 09	"
East Sugar Loaf Mines,	52,643 14	"
Colerain,	55,335 09	"
Stafford,	9,856 18	"
N. Y. Lehigh Coal Co.,	29,492 11	"
German Pennsylvania Coal Co.,	18,652 05	"
South Spring Mountain Ridge,	17,369 10	"
Hazleton Coal Co.,	100,269 06	"
Cranberry Mines,	56,257 07	"
Diamond Mines,	83,335 06	"
Council Ridge,	37,095 09	"
Buck Mountain Co.,	75,143 16	"
Wilkesbarre Coal Co.,	16,006 15	"
Wyoming Coal,	9,602 01	"
Hartford Coal Co.,	7,058 19	"
Total,	887,204 17	"

Lehigh Valley Railroad.

To Sept. 26th.

Wm. Milnes & Co.,	68,622 10	tons.
Ratcliff & Johnson's,	2,860 12	"
Packer, Carter & Co.,	27,270 02	"
N. Y. & Lehigh,	8,941 008	"
Sharpe, Leisenring & Co.,	15,749 05	"
German Penna. Coal Co.,	4,319 02	"
Dobbin & Dehaven,	851 01	
Total,	117,615 00	"
By Canal,	887,204 17	"
Total,	1,004,819 17	"
Same time last year, (Canal)	983,008 08	"
Increase in 1856, so far,	21,810 09	"
The decrease by Canal is	95,808 11	"

CUMBERLAND COAL TRADE FOR 1856.

Total shipped by each Company for the year commencing January 1, 1856, to Oct. 26th.

Cumberland Coal and Iron Co.	154,856.14
Percy & Co.	9,905.06
Ætna Coal Co.	8,[illegible]7.05
Frostburg Coal Co.	
Borden Mining Co.	
Allegany Mining Co.	129,785.00
Carbon Hill Coal Co.	
Wellersburg Coal Co.	
(From the Western port region up to Sept. 6th.)	
George's Creek Coal Co.	78,792.08
Swanton Coal Co.	32,481.18
American Coal Co.	42,876.12
Franklin Coal Co.	22,958.17
Lonaconing Coal Co.	21,888.08
Preston Coal Co.	2,416.02
Hampshire Coal Co.	24,122.11
Total,	528,195.01

THE SUPPLY OF COAL.

It is now evident that the market for Coal cannot be supplied this season. But about two months of the shipping season remain, and perhaps less—and the supply from all the Regions so far, is about 152,000 tons behind the supply to same period last year, including the supply from the new regions. The deficiency cannot be made up for the balance of the season. Last year the increased supply was 680,000 tons over the previous year—and there was a surplus in only a few markets. This year it is impossible to throw into the market any increase over the supply of last year, for the balance of the season. In comparison with last year the trade sums up as follows:

	1855. *Ahead.*	1856. *Behind.*	*Ahead.*
Schuylkill	279,624	146,129	
Lehigh Region	79,892		19,949
Del. and Hudson Co.	75,000	71,584	
Penn. Coal Co.	about the same,		40,000
Wilkesbarre—down river—decrease	30,000	25,000	
Scranton—East, new supply			30,000
	434.526	242,718	89,000
	89,949		
	152,764		

Deduct from the 436,526 tons 30,000 tons, which the Wilkesbarre Region was short last year of the supply of the previous year down the river, and you have 406,526 tons ahead of the previous year at this period. Add to this the deficiency of the trade this year, and it shows a difference in the state of the trade now, compared with the same period last year, of upwards of six hundred and fifty-nine thousand tons.

We care not how brisk the demand may be for the balance of the season, no increase of Coal can be thrown into the market this year—and it is extremely doubtful whether the present deficiency can be made up.—*Pottsville Journal.*

LA SALLE COAL FIELD IN ILLINOIS.

This important coal field has not received the attention which its merits deserve. The principal company at work is the La Salle Coal Company.—From the papers published by this company and the letters of Dr. Norwood, the State Geologist, we have condensed the annexed particulars:

The northen portion of this State as far south as the parallel forming the

northern boundary of the Township in which stands the City of La Salle, contains no coal. This has been well proven by examinations made by able Geologists, of all the formations that lie north of this latitude, which are found to be those belonging below the coal measures, except the drift deposits overlaying the whole and forming the surface earth. These examinations have extended northward to Lake Superior, and no carboniferous strata are found in that distance.

Going southward from La Salle, coal basins are found, and increasing in extent as we move southward, until near the southwestern extremity of the State, when the coal measures are all cut off again.

East of La Salle, coal is found in Grundy and Will counties, but in irregular deposits or basins, and in Will County to a very limited extent. Some of these are so near the surface as to be worked by stripping the surface earth covering it, and others are worked by shafts of moderate depth.

West of La Salle, coal is found in Bureau County, and again in Henry and Rock Island Counties. At all these places, the coal has been worked sufficiently to test its quality.

The basin of La Salle County, which extends into Bureau, although having advantages of transportation superior to all the others, and greater extent of country, with a larger population that must always look to this point for their supply, has been the last in getting fairly developed, because of the situation of the coal hidden at a much greater depth than at the other points mentioned; and requiring the aid of capital, with an organized company, and systematic management, for a successful prosecution of the business.

When coal outcrops at the surface, a very moderate outlay of capital will commence a business of digging in small quantity; but to do it successfully and make a permanent trade, requires system in mining, and the aid of capital, in order to carry on a large business.

In coal mining, the most successful operations are made by securing a large trade that shall be steady to a certain amount, and then increase the supply with the growing demand; and it has been found, where coal mining has beeen established as a regular business, that the demand was always ahead of the supply, and the enlargement of mining operations never kept pace with the growth of the country.

At many localities where heavy mining operations are conducted, there is a busy season and a dull one, in each year, dependent upon and arising from the mode of transportation and nature of the demand for consumption. We are favored in this respect beyond most places, in having a demand the whole year, because of facilities for shipment at all times in any direction by railroad, and for eight months by canal and river. This advantage will be readily understood and appreciated by all those who have in any way been connected with mining operations.

The La Salle Coal Basin.—It has an abrupt termination along its eastern boundary, outcropping at a considerable angle. The line of outcrop is one mile and a half east of the crossing of the Illinois Central and the Rock Island Railroads, thence it extends in a southeasterly and northwesterly direction. The outcrop on the Rock Island Railroad is at the outlet of the Swanson Ravine. Following up this ravine about three-quarters of a mile, which brings us to its head, we find it reaches the level of the prairie, and here the coal is but about four feet below the surface. Continuing on the line of outcrop half a mile further, we find it cut and opened to our view by the Little Vermilion River. From this point its course is right up the valley of this stream for about four miles, and there leaving the river, it suddenly changes to a southwesterly direction and is lost to view in the prairie. On the south side of the Illinois River, the Big Vermilion occupies a similar position with relation to the outcrop to that of the Little Vermilion on the north, but does not run as regularly with it after striking the outcrop, and from the south line of section thirty-six, the river bears away to the eastward.

The Basin is about 18 miles long and 12 miles wide, as stated by Dr. J. G.

Norwood, the State Geologist, after a careful examination of its boundaries, in a large portion of which, he says, workable seams exist.

The Illinois, and both the Vermilion Rivers, where the coal outcrops have high precipitous bluffs composed of shales and limestone, and a retreating slope of drift which is fifty or sixty feet deep within a short distance of the edge of the bluff.—The strike of the coal, as shown by the outcrop, is abouth north thirty-three degrees west. The direction of the dip is at right angles with the strike, and it descends at the rate of one foot in six from the outcrop, for the distance of some twelve hundred feet, and thence continues with a gentle inclination in the same direction until it gradually becomes almost level, gently undulating. The upper workable seam of coal is found to vary in thickness from four to five feet at the different points of the basin at which it is worked. The second seam, which lies 58 feet below the bottom of the upper one, is about six feet in thickness, and has overlaying it and included in this thickness, a seam of cannel coal varying in thickness from six to eighteen inches. About 64 feet below this there is a seam of 27 inches that is not considered of much value. At 135 feet below the six feet bed is found the lower bed, varying in thickness from 27 inches at the outcrop to 3 feet 11 inches a few rods distant from it.

It was generally supposed until a few days since, that the lower bed was about 80 feet below the middle or 6 feet bed. Mr. D. Lathrop, of this place, had a boring made to test the accuracy of observations made at other points, and found the lower bed at 137½ feet. The angle at which it lies where he bored for it, would give the distance at right angles to the dip of 135 feet. It is probable that the bed increases to 4 feet and continues pretty uniformly at that thickness throughout a large portion of the basin. The geological section with this report, showing the coal strata, was made previous to the completion of this boring, and shows the lower bed 80 feet below the 6 feet bed. The distance given between the upper and 6 feet bed, is from the boring made on the land of John A. Rockwell, Esq., at the steamboat basin.

Facilities for reaching market.—As if foreseeing the need of the development of the hidden treasures beneath the surface, the greatest public improvement in this State has centred at this point, nature having first set her seal by making it the head of navigation on the Illinois River. This brought to the same point the termination of the Illinois and Michigan Canal, which has its other terminus in Lake Michigan at Chicago, a distance of one hundred miles. La Salle is also the terminus of the Illinois Central Railroad from Cairo, and point of continuation of the road by the northern branch to Galena and Dunleith, where it meets the Mississippi River opposite to Dubuque. From this branch of the Illinois Central Railroad, every county of the State north of La Salle can be reached by the railroads that intersect it at several points. First at Mendota, by the Chicago and Burlington R. R., giving another connection with Chicago in a distance of 105 miles. Second, at Dixon, by the Chicago and Dixon Air Line R. R., forming a connection with Chicago and with all intermediate towns, and from Dixon west it passes through several rapidly growing towns, striking the Mississippi River at Fulton City. Third, at Freeport, by the Chicago and Galena R. R., by which a connection is made at Belvidere on the line of that railroad leading to Madison and other important places in Wisconsin. Continuing on the Illinois Central R. R., from Freeport the Mississippi River is reached at Dunleith, a distance from La Salle, of 147 miles. Going south again to Mendota, 17 miles north of La Salle, a railroad has been projected, and sufficient stock subscribed to give it a fair prospect of being built, which is to run directly north to Rockford, intersecting the Chicago and Galena R. R. at that place, and connecting at Beloit with a railroad to Madison, Wisconsin, thus giving a direct communication with southern Wisconsin, which is as much in want of fuel as Illinois. At La Salle there is another direct connection with Chicago, by the Chicago and Rock Island Railroad, a distance of 98 miles, and westward to Rock Island 83 miles.

Sixty miles southward on the Illinois Central R. R., is Bloomington, a town of 7000 to 8000 inhabitants, and between it and La Salle are several thriving little towns, the growth of enterprises resulting from the construction of that railroad.

A new railroad is projected to run from La Salle to Lafayette, Indiana, which will open another seoction of the State that will look to this quarter for fuel.

The market for the Coal.—Having described in the preceding pages the position of La Salle and its accessibility from all directions, it must be evident to all that even the present market for its coal is a very large one. The population of that part of Illinois which lies north of La Salle, was in 1850 upwards of 219,000, and in the year 1855 the census gave 380,000, showing an increase of 161,000 in five years. It would be a very moderate estimate to say that three-fourths of this population must get their coal from La Salle, as soon as it can be furnished, it being the nearest point to them where coal can be obtained. We have no means of estimating the market thrown open to us by the railroads in connection with us, which run through the southeren part of Wisconsin, but know that it is large and rapidly increasing; and no doubt it is under the mark to say that there, is at this time, a population of half a million in Illinois and Wisconsin, within the range of our present means of transportation, that can receive coal cheaper from us than from any other place.

The coaling of steamboats at this point is not yet an established business, but there can be no doubt that, before the close of the next season, they will have taken some eight to ten thousand tons. The proprietors of lines of steamboats running on the Upper Mississippi and touching at Dunleith, have given assurances that they will take from this point all the coal they can consume, when it can be furnished them regularly at a fair rate; and there are, besides these, a large number of irregularly running boats, passing up and down the river, that would also coal there as soon as the business was fairly established. The number of steamboat arrivals in all at Dunleith, during the last season, was upwards of eight hundred; and had these coaled at this point, it would probably have required some twenty to thirty thousand tons to have supplied them. This market, with that also of Dubuque, which is opposite to Dunleith, and which of itself probably amounts to at least ten thousand tons more, is open to us by means of the Illinois Central Railroad.

All the towns on the various railroads between us and this point, will of course be open to our coal. The towns on the Illinois Central Railroad for a considerable distance south, are tributary to our general trade, and will naturally come to us for their coal as to their nearest accessible supply.

Besides the numerous places on the various railroad routes to Chicago, there is the enormous market of that city itself, to which we have several lines of communication. The amount of coal consumed in that city for the year 1855 was over one hundred and ten thousand tons; and shows an increase of consumption over the previous year of fifty-three thousand tons. And it must be observed, that this was under the oppressive rates of six to seven dollars per ton, the price charged for the Ohio and Pennsylvania coals. In addition to the above amount, great quantities of coal would be taken by the steamers outward bound, if it could be furnished them. As it is now, they must bring their coal for their return voyage with them from Cleveland or Erie. The number of steamboats and propellers at the port of Chicago for the year 1855, was a little short of one thousand; and had they coaled freely as they would have done had coal been selling at a reasonable rate, it would probably have required over fifty thousand tons to have met their wants.

Here we have a market of more than one hundred and sixty thousand tons, and one which is increasing with astonishing rapidity. Into it, by means of the Illinois and Michigan Canal, we can deliver our coal at the present time and sell it there at the rate of three dollars and fifty cents per

ton, which will cover all expense, and allow an ample profit, and within two years, it can be done for $2,75. We can deliver coal there at as low a figure as the Ohio coal can be put into Cleveland, or the Pennsylvania into Erie, and consequently have in our favor the cost of transportation from these places to Chicago, and this is our present competition. It will be seen at once that the coal from this point will command the Chicago market.

Another great source of demand will be from the railroads, which are so numerous and prosperous in this State. The high and increasing rate of cord wood has already turned the attention of railroad directors to bituminous coal and coke, as a substitute for locomotive use. The expriments made have met with much success, and we may expect a demand for this kind of fuel on railroads, sooner than any adequate supply will be prepared to meet it.

The La Salle Company's property.—This is situated directly on the Illinois Central Railroad, which touches its western boundary. It consists of 240 acres in one body. All but 40 acres which is much broken, lying on and east of the Vermilion, is fine farming land and mostly under cultivation. The south line of the farm is three-fourths of a mile north of the Canal and Rock Island Railroad. There is now on the land, a farm house somewhat out of repair, an excellent barn of large size, and six houses for miners, in good order, four of them built within the last year.

The upper bed of coal outcrops on the east side of the farm in Swanson Ravine. It has been worked there to some extent, and entries driven down the dip for 800 feet. The coal was found of good quality, and at the lower end of the entry had increased to 4 feet 10 inches in thickness, being only four feet at the entrance. The coal has been worked to some extent in the outcrop, but the steep grade of the main entries, from the rapid dip of the coal, renders it expensive working, except by an engine, and then a track should be laid down Swanson Ravine to the Canal and Rock Island Railroad. The section of the strata shown on the bottom of the map, is taken on the south side of the farm. The outcrop of the upper bed continues nearly in the direction of Swanson Ravine across the northeast corner.

Excepting about five acres on the northeast corner, in which the upper bed may be wanting, the land contains the three workable beds throughout its area. Allowing one-fourth for loss and waste, this would give about 4,000,000 tons, or 100,000,000 bushels of 80 pounds, of marketable coal that can be raised from the tract.

The surface value of the tract for farming, is worth, as lands sell here, $85 per acre, amounting to $8,400.

The expenses of the Company the past year for sinking shaft, erecting machinery, miners' houses and opening the coal at the outcrop, have been in round numbers, $18,000.

The basis for a valuation of the property, would be thus:

100,000,000 bushels coal at ,01	$1,000,000
Surface value of farm.	8,400
Expenditures for shaft, machinery, and permanent improvements, . . .	18,000
	$1,026,400

If we make the usual estimate of the profit in working at 3 cents per bushel, this will give a total profit on the working of the coal of $3,000,000.

Of the fire clay underlying each bed of coal nothing has been said, though its quality is superior; and a large and profitable business could be done in working it into fire brick, using the waste coal and slack for burning.

The extensive beds of fine limestone at the surface, furnish the material for making a good strong lime, the demand for which would be almost unlimited.

The Company have put their capital stock at only $500,000, and will not increase it unless with the addition of more lands for mining.

The expenditures of the Company have been mostly in cash, and their liabilities at this time do not amount to one thousand dollars.

The shaft.—This is located to reach the greatest amount of coal from the tract with the least expense, and secure perfect drainage. The top of it is 60 feet above the level of the Little Vermilion. The object of this is to get an easy connection with the Illinois Central Railroad, which will be made by a side track of 1500 feet.

The coal was reached in the shaft on the 29th of March last at a depth of 198.8 feet, and the thickness found to be 4½ feet. It is now ten feet below the coal, or a total depth of 218 feet, leaving a sump to receive the water.

The shaft sinking is discontinued at present in order to get the workings well started in the coal, but it should be carried down this season to the next bed of coal on account of its quality being superior to the upper bed, and its greater thickness and economy of working. Both beds can be worked at the same time, without incurring additional expense outside. The coal works freer and can be mined at half a cent per bushel less than the first bed. It is not proposed to work the lower bed until the upper and middle bed workings are well advanced.

The vertical section of the shaft exhibits all the different strata that were penetrated and the thickness of each, with the aggregate thickness given at each workable coal seam. The size of the shaft is 6½ by 12 feet inside the timber curbing, which extends from the bottom to within 15 feet of the top. This is separated into two compartments by a division in the centre which is made air-tight, thus making two shafts of one; by this means perfect ventilation can be secured for three years or more, until both sides are wanted for hoisting—one side being used for hoisting and the other for draft from the mine.

When the extent of the workings becomes such as to require the use of both sides for hoisting coal, another shift of smaller size for air can be put down, or an air passage can be driven through the coal to the surface at the outcrop.

With the present arrangement for working one side, the shaft has a capacity for 500 tons per day, or 150,000 tons per year, worth at the mines $2.00 per ton, or $300,000.

A fine steam engine and hoisting machinery, built to order for the Company, have been in use several months for sinking the shaft. It is arranged for hoisting at the rate of 300 feet per minute, and has sufficient power for hoisting to the full extent of the capacity of the shaft, and a surplus power for draining the mine of water.

The amount of water found in sinking the shaft was small, being only 30 barrels in 24 hours, all from one stratum, and a constant supply.

Quality of the coal—The lower bed compares very favorably with coals of high reputation. The middle or six feet bed is scarcely inferior to the lower bed, and its greater thickness will render it very profitable working. The seam of cannel coal in connection with it, gives additional value to this bed. The quality of it is good, but not equal to the best cannel. In appearance and in burning, it seems to be fully equal to the celebrated Kanawha River coal that is much used in Cincinnati.

The upper bed is a little inferior to both the others, but is still a fine coal. There are two qualities in the bed,—the lower half being the inferior portion is harder than the upper part, which compares well with the lower bed.

We have been using the coal of this bed for eight months in the furnace of our engine, and find it an excellent coal for generating steam. In burning, the residuum is ash and cinder, and lives the great bars perfectly free and clear. The grates in our furnace are as clear now as the day they were put in.

The quality of the coal will be best appreciated by a comparative analysis with other well-known coals, which will be found in the accompanying report of Dr. J. G. Norwood, State Geologist of Illinois.*

* See October No. Mining Magazine.

The following letter from Dr. Norwood answers many important particulars respecting this coal field at La Salle:—

SPRINGFIELD, ILL., March 4, 1856.

H. S. BEEBE, Esq., and others:

Gentlemen:—Your letter asking for information respecting the coal beds in your vicinity, has been received, and by a direction of Gov. Matteson, I proceed to answer such of your inquiries as my knowledge of the geological formation of Peru and vicinity will allow.

1st. "What is your opinion of the coal field in which Peru is situated; how many beds of coal does it contain; what is their thickness; and which is most valuable for working?"

The extent of the La Salle County coal field is about eighteen miles in length, and twelve miles in breadth, embracing an area of two hundred and sixteen miles, in a large portion of which workable seams of coal exist. In some parts the various beds are favorably situated for working by means of drifts or levels. Where that cannot be done, all the beds may be worked by means of shafts, varying in depth accordingly as the shaft is opened in the low lands of the river bottom, or in the high lands forming the general level of the country.

There are five beds of coal at Peru, three of which are workable. The lowest seam is from twenty-seven inches to three feet thick at the outcrop in the valley of the Little Vermilion, but increases in thickness as it descends into the basin in a south-westerly direction. At one point where it has been penetrated by a shaft, it is nearly four feet thick.

The next bed in ascending order, called the "middle bed," is six feet thick, and lies about eighty feet above the lower bed; the intervening strata consisting of slate shales, lime-rock, and stone, and fire-clay. This bed, where it is worked near the mouth of Swanson Ravine, has in the upper part from twelve to fifteen inches of cannel coal, and this will, in all probability, prove to be the case at Peru. On the eastern side of the axis, in the southern part of the county, it is eight feet thick. It is not always, however, to be relied on; being interrupted by horsebacks and cross layers of clay. These continue for the distance of a foot, or a few feet, cutting out the coal and thinning the seam; but after driving through them it is found of its usual thickness again.

The next, or upper workable bed, is four feet thick at the outcrop, and soon reaches four feet and a half, as it proceeds down the dip. The strata between this and the middle bed consist of slate, shales, clay, sand-stone, thin bands of lime-stone, and in some localities a thin seam of coal. The shales and clays make up the greater part of the depth, and the sand-stone the next greatest. This bed lies from fifty to fifty-five feet above the middle bed, the intervening strata varying in thickness at different localities.

From the upper bed to the top of the lime-stone on which the northern part of Peru is situated, there is a depth of about a hundred and ninety feet, all of which has been penetrated by the shaft of the La Salle Coal Mining Company. From the Manager of that Company you can obtain an accurate account of the material through which the shaft is sunk.

There is, then, underlying Peru, a total thickness of from twelve to thirteen and a half feet of workable coal, all of which can be mined as favorably and as profitably as the coals in any other part of the basin.

2d. "Can the coal be worked in the bottom, under the river?"

Yes.

3d. "What is the quality of the coal generally, and of each bed, with reference to the others; and which is the most valuable for working? And further, how do they compare with coals likely to come in competition with them, as those of Ohio and Pennsylvania?"

This question can only be answered by reference to the coals taken from the mines east and south of La Salle; and of these only the lower bed has

been analyzed.—They all belong to the "light bituminous" variety, with the exception of the upper part of the middle seam, which is "compact." Of the value of this coal for the generation of steam, and its adaptation to manufacturing purposes generally, you can judge from the following comparison of the average amount of fixed carbon which it contains, with the average amount contained in the bituminous coals of Pennsylvania and Ohio; recollecting that the heating power of coal depends upon the amount of its fixed arbon, and not upon its gaseous products.

	Carbon.
Lower bed La Salle County Coal, average of three specimens,	58.07
Ohio, average of four samples,	54.98
Pennsylvania, average of 6 specimens,	46.58
Briar Hill Coal, Ohio,	56.41
	Per cent.
Average amount of ashes in the three specimens from La Salle County lower bed,	4.05
Average amount of ashes in the four samples from Ohio,	5.98
Average amount of ashes in the six specimens from Pennsylvania,	10.81
Amount of ashes in Briar Hill coal, Ohio,	8.46
	Lbs.
The weight of a cubic yard of La Salle coal (lower bed) is	21.46
Of Indian coal,	21.26
Of Kentucky coal,	21.06
Of Ohio coal,	21.40

From this comparison it will be seen that a greater amount of tons is contained in an acre of La Salle coal than in either the Indiana, Kentucky, or Ohio seams of the same thickness.

The middle or six feet bed is very little inferior to the lower seam, and in connection with the cannel coal and its greater thickness, will be found equally as profitable, if not more so, to those who mine it, notwithstanding its interruption by horsebacks. It is suitable for almost every purpose for which fuel is used.

The upper workable bed is somewhat inferior in quality to the middle one, but improves as it is penetrated from the outcrop. In two of the drifts now worked, it is found to be almost as profitable as the other beds, but will not bear transportation so well, nor is it so marketable.

4th. "State the dip and direction of the beds."

The strike or direction of the beds is North 38° West, and the dip at right angles to the strike.

5th. "What is the depth of each bed below the bottom at Peru?"

Judging from my own observations together with the experiments already made, the upper seam can be reached at the depth of about 185 feet—the middle one at less than 190 feet—and the lower bed at about 270 feet.

6th. "Where are the best points in the vicinity of Peru for sinking a shaft?"

At any point above high water mark, from the mouth of Spring Creek up to the City, and along Water Street to the eastern boundary of the City, and thence along the Canal as far as "Egleston's shaft."

7th. "Where can a market be found for these coals?"

From Joliet to Chicago.

8th. "What would be the difference in the depth of a shaft sunk in the bottom at Peru, and one sunk at the bluff."

From 60 to 75 feet, depending of course upon whether you selected a ravine or the general level.

Your main object, I apprehend, in addressing me is to know my opinion with respect to the existence of coal seams at Peru, and the feasibility of working them profitably, together with the value of the coals. I have answered all your queries bearing on these points to the best of my judgment, which has been formed after a careful and minute examination of the La Salle coal basin at every accessible point.

As to your inquiries with regard to the cost of sinking a shaft; of the necessary machinery; and of elevating the coal, I must refer you to those

who are already engaged in such operations in your immediate neighborhood.

When you have sunk your shaft to the first bed of coal, I will if requested, offer a plan for working the mine.

I am, very respectfully,

Yours, &c.,

J. G. NORWOOD, *State Geologist.*

CUMBERLAND COAL PRICES.

We have been watching with great anxiety the effect that the increase of freight would have upon the coal operations, but cannot come to any satisfactory conclusion. On Monday last we took a trip up the George's Creek valley and learned that several companies contemplate slackening operations, and one company has already stopped for the present. There seems to be a great deal of confidence manifested by that portion of the railroad directors in favor of the increased tariff, that all will work right. The Baltimore American, generally pretty correct, says:

"From the most reliable source, the fears that have been so generally expressed that the recent action of the Baltimore and Ohio Railroad, in advancing the rates, would result injuriously to both the Railroad and Coal interests, are likely to prove entirely unfounded. The advance in question, coupled as it was with an assurance of increased facilities of transportation on the part of the road, has, we are authorized to state, met the full approval of the most important consumers of the East.

"The Company has, we are informed, within three days past, received such assurances and guaranties from the highest quarters as warrant it in urging forward the preparation by our Baltimore Mechanics of the additional five locomotives for this particular trade, and it is said that it is likely to do an unusually heavy month's work in October."

Now, if the information is correct, we would suggest that the Baltimore and Ohio Railroad Company give like assurance to the various coal companies. If that company have guarantees from the East that the coal will be taken at the advanced price, let the Railroad Company guarantee that all coal delivered at Piedmont and Cumberland will be paid for, and the companies can go to work. But when such kind of flattering statements appear in opposition to facts, the companies are left in doubt. All operations that require the amount of labor and expense that the mining operatives require, also require some reliable basis upon which to operate. Were they certain that every ton of coal delivered in market would meet with ready sale, at the present prices, they could ship coal so fast that the Baltimoreans would begin to think the city would be buried beneath the accumulatory mass of "Alleghany Diamonds." A few days more will test the matter. The winter is drawing nigh and coal being deficient in market for a winter's supply, coal buyers have got to pay the price or seek fuel somewhere else. Hence, the prices must be sustained or a suspension of coal operations must take place.

EXPENSE OF SINKING SHAFTS.

The interesting correspondent of the Pottsville Journal presents some important facts relative to the expense of sinking shafts in the English collieries, from which we obtain the following:

The writer has thought, that if the regular order of these letters, which have been hitherto devoted to the successive description of the Collieries visited by him in this instructive little Island, were interrupted to give place to a chapter or two on the *expense of sinking Shafts*—wherein he should gather, in as condensed a form as possible, all the information gleaned throughout his English tour from reliable sources *at the mines*, that such summary would be of considerable interest and practical value to operatives in Pennsylvania.

In our new country the opportunity of comparing notes with Old England—where Coal was sunk for and worked a couple of centuries before the discovery of this Continent—is one eagerly availed of whenever presented. Any thing related to the subject of shafts especially, is read here with great interest; but information of this sort, besides being scattered and not too abundant in our country, has not usually where it exists, the merit of being practical. We may read that the winning of South Hatton Shaft cost over half a million of dollars—but as it will be a hundred years at least, before a pit of the extent of these well-known ones in the Newcastle Coalfield becomes thought of in our country, the information, though curious, is of no practical value. What we want, is something that can be compared with analogous conditions here, and by its application, ever recurring daily problems satisfied at home. In England itself, of course these deep shafts are not the rule but the exception, and of Collieries working under similar conditions with those of Schuylkill County, there is no end.

In some of the busiest Coalfields in England,—that land of *thoroughfares and capital*—the fields are spangled so thickly with pits' mouths that you stumble upon them at every step, and in Staffordshire you must take good care or you will stumble *into* them; agriculture is abandoned—the pick and the drill supplant the rake and the hoe—the farmer is at a discount and the miner at a high premium. Here a new shaft is an every-day matter—each morning sees numbers begun, and numbers finished.

But in our country, a shaft is still a curiosity. To sink one of any depth, is an affair of moment. An operation so uncommon, is not to be undertaken without solemn forethought and serious calculation. Perhaps they would be undertaken oftener, if it were not for the uncertainty of the expense.

"Here," says the operator, "my slope has penetrated many hundred yards into the coal bed—I find the air is getting bad, and it is only with great difficulty that a regular current is kept up—in warm summer weather, indeed, it utterly fails me, for then the downcast air is so lightened by the increase in temperature, that its weight is not sufficient to overcome the equilibrium between the two columns, and the air in the mine remains in almost a stagnant condition. Men cannot work in an atmosphere of this sort, and I know not what hot day may produce an explosion. For when midsummer heat has so lessened the weight, and consequently the pressure of the air against the face of the coal and in the abandoned goaves, what a premium is given to the issue of *Firedamp*. This was before restrained, but now it escapes unseen from every pore and crevice, and accumulating by the feebleness of the ventilation may some day ignite at the lamp of the miner, and produce one of those awful scenes here, which I had never before thought of but in connection with English coal mines and deep ones. The fact is, I ought to sink a shaft from the surface, then the air would ascend and descend without impediment—it would be a shorter column, and there would be much less resistance—the miners would always breathe good air and could get more coal with greater satisfaction. This alone, in time, would probably repay me for the outlay, but then the possibility of an explosion would be provided against, with a good furnace; *now* it would be out of the question—pumping operations could be carried on with much more facility, there would be a saving in length of pump-rods and pipes, and a considerable saving of power in working direct. These and many other inducements convince me that I should sink a shaft. But the cost of these things is said to be enormous. Perhaps eight or ten thousand dollars I might have to sink in carrying it through. These shafts, to be sure, are universal in England, and the average price at which one can buy coal in that country, at the surface of pits ranging from 100 up to 1800 feet deep, is no more than $1 25 per ton. I don't know why shafts here should not cost much more by the fathom than shafts there. But for the uncertainty of the business, I would certainly sink one."

Thus reasons and argues the operator. It shall be my endeavor in this and a few succeeding letters, to remove as much as may be of this uncertainty,

by showing what the cost actually was, of a number of shafts under various conditions, and located in different parts of England.

And first, as the Rhymney colliery in South Wales was alluded to in my last letter, let us proceed to inquire the cost of sinking shafts at those extensive Coal and Iron Works.

At Rhymney, most of the coal is worked out *by levels*—but there are 7 upcast shafts for purposes of ventilation. None of these are used for the raising of coal; they are most of them about 110 feet, and vary in diameter from 6 or 8 feet, up to 17 1-2 by 10 1-2, the usual dimensions of a "Water Balance Pit" in Wales. The total sectional area of these upcasts is nearly 500 feet. They were made at an entire cost, cash, of from $725 to $1,200.

A new pit just sunk at the time of my visit, 8 feet in diameter and 108 feet deep, cost as follows:

For sinking, ...	$4 00 per foot of depth.
For walling, ...	2 50 " " " "

Total $6 50 per foot, equal to an entire cost of about $7 25 for the shaft. The *wallings* is with brick, and includes the insertion of a short length of iron curb, to keep back the water. The majority of the shafts at Rhymney, are well represented by this one.

Another shaft intended as a "Balance pit," not long completed, of which the width is 17 1-2 by 10 1-2 feet, and the depth 105 feet, had cost as follows:

For sinking, ...	$9 75 per foot of depth.
Walling and other expenses, ...	1 75 " " " "

Total $11 50 per foot, or about $35 per yard, at which rate the pit was finished complete, for little over $1200. So we see that in this instance, increasing the sectional area of the shaft nearly three times, has only increased the expense about 1 2-3 times. W. J. P.

MASON AND CO.'S BOARDMAN COAL-BURNER.

We have examined the coal-burning engine which has been running since last October on the Providence and Worcester railroad; and we have conversed with Mr. French, the Master Mechanic of that road, and with engineers in other establishments in Providence, who have seen the engine at work, and ascertained the costs of running, etc. From their unanimous report it appears that the engine performs well, and at about two-thirds the expense for fuel that it is required for a wood-burner doing the same work.

Mr. French states that the engine makes steam with a 4 inch blast orifice about as well as with a smaller one It is now using a $3\frac{1}{2}$ orifice, and has used several smaller sizes. The first used was $2\frac{1}{4}$, which threw out large quantities of coal; a larger orifice was tried, which softened the blast; and the proportion was found, by trial, which made steam enough, without too much disturbing the fire. This ease of draft is due to the immense flue area; there are 340 tubes, $2\frac{1}{8}$ inches diameter. On the other hand, tending to impair the draft, there is an excessively large smoke-box, and a flame-chamber of sufficient size for a man to work in to set the tubes. We may therefore expect that the blast orifice will be made equal to the steam-port, and the back-pressure will be practically extinguished.

In the first trials of this engine, with Cumberland coal, there was considerable smoke. To effect the combustion of it three perforated air pipes, open at the front end, were introduced, by which means air was injected throughout the mass of smoke; and the combustion was rendered so nearly perfect that very little smoke could be seen; and it was not deemed necessary to alter the proportions of the air pipes. It is not supposed, either by the builders or the parties with whom we conversed, that these proportions, first tried, are the best; on the contrary, all anticipate considerable improvement; but it is considered as satisfactorily proved that the large flame-chamber, and the injection of air into the smoke, will effectively burn the smoke of bitu-

minous coal; and that this engine, with the few experiments made upon it, has been made to work with less dirt to the train than any wood engine on the line. If any dust be thrown out, it is not kept from rising by a spark-arrester, but it is projected upward out of the way of the train; and there is ample reason to believe that a practically perfect combustion will be secured at all times after the fire is fairly lighted.

Among the advantages of this form of boiler we may enumerate the following: The tube-sheet is not exposed to the direct action of the fire; consequently, it will last better, and the tubes need not be much stopped up by ferules; the liberal flue-area secured by this, and by the great number of tubes, very much diminishes the resistance to the draft; the dust carried over is in a great measure lodged in the passages; and the facility of repairs is as great as it is in the common boiler.

The large flame-chamber of this boiler is the same in principle as that in McConnell's boiler, though different in form; and the injection of air to perfect the combustion of gases is the same in principle as the method he applied, by means of tubular stays in the fire-box. It is not necessary in coke burners, to admit air above the fire, if the draft is strong, and the fire of moderate depth; and for this reason McConnell's plan has not found much favor; it may, however, afford some suggestions as to the most convenient way of admitting air where it is really needed, that is, where there is a great volume of carburetted hydrogen to be burned.

This engine has cylinders $14\frac{1}{2} \times 22$ inches; 5 feet drivers; 9 feet surface in fire-box, 72 feet in the flame-chamber, and 872 in the tubes; grate area 14 feet; blast orifice $3\frac{1}{4}$ diameter; chimney 14 inches. There are 60 feet of heating surface to 1 of grate; and the ratio of the blast area to the grate is $\frac{1}{181}$. These proportions differ from the most successful of the English engines, which have from 70 to 96 feet of heating surface to one of grate, with blast orifices somewhat larger, and chimneys 1 to $1\frac{1}{2}$ inches less diameter than the cylinders. For wood-burners these proportions may be better; and it is supposed that a large grate is required. We do not, however, see the reason of this opinion; and would suggest the experiment of a few bricks to lessen the grate area, and to increase the intensity of the combustion. Fuel is never completely burned at a low temperature, especially the volatile part of it; and when the chilling surface of the fire-box, instead of non-conducting substances, are contiguous to the fire, to absorb the heat, it is necessary to concentrate and intensify the combustion in order to render it nearly complete. If we look at the blue flame from the chimney of a steamboat that burns anthracite coal, at night, and watch the streaks of bright flame that dart upward on its surface, we may readily estimate that 20 per cent. of the fuel is wasted. On the other hand, a locomotive that has a thin fire of large coke, with a strong blast, keeping a white heat, completely burns its gases; no carbonic oxide remains; but every thing combustible is consumed, and made to assist in the generation of steam. And with the ample flue area attained in this boiler, which is favorable to the draft, we think that a smaller grate, and more intense combustion, may be made to give the required amount of steam, if due attention be paid to the proportions on which the draft depends, namely, the size of smoke-box, the diameter of chimney, as well as the other parts which we have mentioned as already well proportioned.

It cannot be supposed that it is unimportant whether a chimney is considerably larger or smaller: there must be a certain size which is best; and it has been found that exchanging the chimneys of two engines that were alike in all other respects, but very different in the power of steaming, that the chimney made the entire difference, and the smaller chimney made the most steam with a given blast orifice, and allowed the largest orifice. It has also been found that filling up a portion of the smoke-box considerably increased the power of steaming. These matters cannot be conveniently tested by the builder; but master-mechanics, when business is not pressing, can usually find time to try them; and we are glad to observe that they are exerting themselves more and more in this way.

As the flue-chamber of this boiler occupies all the room inside the framing between the front driving axle and the truck, it has been necessary to place the eccentrics outside upon a reverted crank. They are made small, and thoroughly finished; and have a very agreeable and almost compact appearance. To prevent too much projection of the eccentrics and link, the connecting and parallel rods are joined in the same vertical plane, the strap of the connecting-rod being forked to embrace that of the parallel-rod, both centring upon the same pin. The arrangement proves entirely satisfactory. Mr. French informs us that the engine has been thrown off the rails, and nearly upset, without straining the joint.

Since the above was written, we have seen the "SLATER" at Worcester, running at moderate speed, with a light load, and standing, firing, etc. The coal used was Cumberland, just as it comes from the vessel, mixed lumps and fine dust. When this mixture is stirred, while the engine is standing, some black smoke issues, and we are told by the engineer, Mr. Grover, that there is often a little smoke when fresh fuel is put in while running; but while we saw her running, there was not a trace of smoke visible; and we were told by all about the depot at Worcester, as well as at Providence, that the smoke is completely burned, with the exceptions above stated.

The air pipe, which is about four inches diameter, is provided with a damper, which is kept but slightly open, and not varied in its opening. When it is closed there is much smoke.

The steam appears not to work so dry as in several other engines of Mason's which we saw. The coke-burner, which we rode on, with a pressure varying from 90 to 120, kept her steam dry—generally invisible; and a large engine on the Western road, with a pressure from 100 to 125, following six inches, kept her steam invisible all the time; but the Boardman boiler, which is not allowed to exceed 100 lbs., puffed out continual white clouds.

We presume that the very delicate differences which make the steam foggy or transparent, may be made in this boiler; if so, it may be considered eligible in all respects.

A wood-burner of this weight would drag 40 cars, in the time allowed, between Providence and Worcester; but 36 is the largest number given to this engine. If, however, the coal were in lumps of proper size, instead of such stuff as we have described, there cannot be a doubt that she would do more work,—probably she would fully equal a wood-burner in power.

Three and a half to four cords of wood, costing on this road from $24 50 to $28, is the quantity used for a round trip; 2½ tons of coal supplies this engine at a cost of $15. Allowing for the difference of work, it is estimated that she saves a full third of the cost of fuel.

This engine has been constantly at work since October last; and $75 only has been charged to her for repairs; and this has been partly for blast nozzles, and other matters of experiment; and in general has been so satisfactory that the company has advertised two wood-burners for sale, intending to replace them by two engines on this plan. One is sold; and it is understood that it is to be replaced by one of the four now building by Mason & Co. Another is for the New Jersey Central; another for Lehigh Valley; and the fourth, it is expected, will go upon the Lowell road.

We have taken pains to inquire of all persons whom we have met, who were able to judge of this engine, and likely to be unbiassed; and we have met with no one who does not consider that it is a highly successful experiment in coal-burning; at the same time it is not claimed by the builders or others, that it is in all respects right. The drawings for the engine now building are in some points altered; and we suppose that in this case, as in most others, experience will be required to complete the proportions.—*Advocate.*

STATEMENT OF THE DAILY OUTPUT OF COLLIERIES IN SOUTH WALES—IN TONS OF 2240 POUNDS:

	Tons per day.
Pontypool Works,	800
Abersychan "	600
Vorteg "	450
Blen Avon "	500
Nantyglo "	800
Ebbw Vale "	1100
Rumney "	900
Cyfartha "	1600
Dowlais "	2000

The last of these, *Dowlais*, one of the great Merthyr Tydvil establishments, with the enormous output of 2000 tons of coal daily, is the largest Ironwork in Wales, or in the world. It possesses no less than 18 *blast furnaces*, and the capital invested is nearly eight millions of dollars. But extensive as this is, it does not much surpass many of its neighbors, which thickly stud the vicinity of Merthyr with their stacks and machinery. The Cyfartha works include 17 blast furnaces and run out weekly 2000 tons of pig iron.

STATEMENT OF COAL CONSUMED WEEKLY AT THE RUMNEY IRON WORKS, SOUTH WALES.

	Tons per week.
By 8 Blast furnaces,	2000
" Refining furnaces	25
" 58 Puddling furnaces,	1000
" 27 Balling furnaces,	400
" 9 Reheating furnaces,	100
" 8 Forge and colliery engines, (400 horse power),	400
(The boilers of the blast engines, 4 in number, of 400 horse power, are fed with the waste gases from the furnaces).	
" 9 Locomotive engines,	250
For heating the blast,	150
Total in the manufacture of iron,	4325
Allowance to 1800 hands, representing a population of 10,000—at $1 00 to $1 50 per ton, delivered,	400
Sold to neighbors, &c.,	75
Steam Coals (mined per contract, for sale to the steam navy),	2000
Total amount of Coal mined at Rhymney,	6800

In these works are invested 8½ millions of dollars!

FUEL FOR LOCOMOTIVES.

Mr. Hale's report of the cost of fuel on the Boston and Worcester Railroad, in the year 1855, and experiments for testing the success of coal-burning engines in reducing the cost, as published in the "Boston Daily Advertiser," of the 11th, has excited much attention. The result, published at the request of the Worcester road, over the signature of Mr. Hale, for 17 years President of that road, is as follows:

For the purpose of ready comparison, I here recapitulate the prominent results, beginning with the computation based on the year's operations, and followed by those based on the experiments for burning coal.

1. *Wood-burning Engines. Average for* 1855.

Weight of train, average both ways,	153 46 tons.
Tons 1 mile per trip,	68 28
Cost of fuel per trip of 44½ miles,	$18,69
" " mile of each train,	41,9c.
" " ton per mile of do.	0,273
" " ton of goods do.	0,576

1. *Coal-burning Engine Hecla, with Baker's Curves.*

Weight of train, average both ways,	149,16 tons.
Tons 1 mile per trip,	6,637
Cost of fuel, per trip of 44½ miles with wood for kindling,	$7,01
" " per mile of each train,	15,75 cts.
" " per ton per mile of do.	0,1056
Pounds of coal and wood per trip,	22,88
" " " per mile of the train,	54.4

BLOOSBURG BITUMINOUS COAL.

A recent correspondent of the Pottsville Journal thus describes the region and the mining of coal at Bloosburg, Pennsylvania. No particulars of this region have recently been presented in these pages.

Bloosburg is 240 miles from Buffalo, 340 from New York and about the same distance from Philadelphia by rail, though the locality is much nearer our city in a direct line, being but 80 miles from Williamsport, and probably the nearest Bituminous coal field we have in this S ate to the Atlantic cities—yet strictly speaking, it is not a distinct coal field, being part of the great Bituminous coal formations, commencing at Bloosburg and extending through some of the adjoining States to the Mississippi Valley, composing the greatest coal field in the world.

There are two coal companies mining coal at the Bloosburg mines, one of them the "Bloosburg Coal Company," which has been in operation for many years, and the other the "Tioga Improvement Company," established but recently. Both of these are doing a safe and respectable business; yet according to our ideas of mining, we think the business might be economically increased if the demand for the coal would warrant it. About 100,000 tons are mined and shipped from the Bloosburg and Morris' Run mines annually. It is shipped over the Tioga road, which is 40 miles in length to Corning, and from thence distributed by rail, canal and lake navigation to Troy, Albany, Buffalo, and the numerous manufacturing towns and cities in their vicinity.

The coal is very good for steam, smithing and blacksmith purposes, but the veins which are now worked do not appear to contain enough of volatile matter to make a good gas coal. There are several overlying and underlying veins that are not yet worked, and the probability is that some of them, particularly those overlying, will make a desirable *gas coal.*

The veins are generally small, but so advantageously placed by nature that the mining is easy, cheap and convenient. We went through the mines of the "Tioga Improvement Company," with Mr. Young the Mining Superintendent, and though we had to go almost on "all fours"—the vein being less than four feet thick—we still thought the interest and incidents of the trip into the bowels of the earth, compensation enough for tired limbs and aching back.

The mode of mining is widely different from that pursued, even in our flat veins in Schuylkill County, and in some cases we must allow it to be superior, because, by the system pursued, all the coal can be extracted, and that too at a low cost. Our miners will scarcely believe that the coal from this vein can be mined and delivered at the bank for 44 cents per ton; yet cheap as this coal is mined, we can still see room for improvements. The fact is, I have not visited any one distinct region, without seeing a general want of uniformity; that is—in one place the mining is done for a low figure, but the transporting or preparing is neglected, and in another the outside improvements are almost perfect, but the mining, pumping or ventilation is at fault. I do not intend to apply these remarks to any particular place or region—they apply generally—and the reason of it is, that almost every one has a plan of his own to pursue, which may be good enough in some respects, but will too often be found defective in others. If all these plans could be analyzed and systematically arranged by some practical yet scientific man, all those improvements, or many of them, could be combined and put to some purpose in mining.

PURIFICATION OF COAL GAS.*

Even those who insist on the comparative purity of our metropolitan gas have admitted, so far as regards one of the most obnoxious of its defilements, namely, sulphuret of carbon, not only that it *is* contaminated with this impu-

* From the London Builder, No. 525.

rity, but that all endeavors to withdraw it, short of destruction of the gas itself as an illuminator, have hitherto been fruitless. It ought to afford the gas companies high gratification, therefore, to learn that it is positively asserted that this grand desideratum has at length been attained, and that the alleged means of withdrawing, not only the sulphuret of carbon, but at the same time the ammonia with which admittedly their gas is also contaminated, are so simple, so available, and so easily applied that no new or expensive apparatus whatever is requisite in order to accomplish an end which will not only remove more than one constant source of mischief, but greatly enhance the illuminative power, and hence the value of their gas, and that, too, at a cost to themselves almost nominal. All that is necessary, it is stated, is to use strata of hydrated clay along with the lime usually employed in the purification of coal gas. The efficiency of this mode of purification has already been tested, it appears, at the Wakefield gas works, on upwards of 8,000,000 cubic feet of gas. The discovery is a practical one, which, in fact, has been patented jointly by the chairman of the Wakefield Gas Works, Mr. W. Statter, and another gentleman, also resident of Wakefield, namely, the Rev. W. R. Bowditch.

Hydrated clay, like some few other interesting chemical substances, forms threefold combinations, and so, in this case, effects its purpose. It not only unites, it is said, with the ammonia of the gas as with a base, but at the same time with its sulphuret of carbon as with an acid, and thus removes both of these noxious impurities from the gas exposed to its influence. Its good offices are said to be not even limited to these; as, in alternation with the lime of the usual purifiers, it assists in removing tarry vapor and other impurities.

The illuminative power of the gas, moreover, is thus said to be positively increasable from 22 to 33⅓ per cent.

The following results are given as rather below than above the average of a considerable series of experiments:—

"Feb. 14th, 1854.—Gas made with one-seventh cannel coal:—Lime purification: 5 feet of gas burnt per hour gave light equal to 12¼ sperm candles. Clay purification: 5 feet of gas burnt per hour gave light equal to 15 sperm candles. Gain: Light of 55 candles per 100 feet of gas, or 100 feet clayed equal to 125 limed (nearly.)

"March 2d and 3d.—No cannel coal used:—Lime purification: 5 feet of gas burnt per hour gave light equal to 11¼ sperm candles. Clay purification: 5 feet of gas burnt per hour gave light equal to 15¼ sperm candles. Gain: Light of 75 candles per 100 feet of gas, or 100 feet clayed equal to 132¼ feet limed."

On this point the patentees say:—

"An increase of light, ranging from 1 4 to 1 5, is an improvement upon which most gas companies would have felicitated themselves had it, and *it only*, been attained by superior management, at a cost of no more than ½d per 1000 cubic feet; the production of light is the object of gas manufacture, and the advantage just named may be expressed commercially as an increase of about ¼ of the article produced, at an expense of 1-40th of the cost of production—gas being assumed to cost 1s. 8d. per 1000 feet. Practice cannot but receive with gratitude the boon presented for acceptance by her parent Science."

Of course we are not blind to the circumstance that the patentees of this invention have a personal interest in giving as high a coloring as possible to the alleged advantages of their patented discovery. We merely quote their statements in order to show that it is not only the duty but the self-interest of the gas companies to look into this matter, and at least to give the proposed method a fair trial, since they acknowledge that the removal of sulphuret of carbon is a great desideratum which is yet to be realized. There is, moreover, we think, a high probability that there is little or no exaggeration in what is alleged. The result of the use of clay at Wakefield is distinctly stated to be uniformly successful, and to bear out all that is said of its value.

Clay or alumina is one of the cheapest and most abundant substances in nature. Its cost, therefore, is out of the question, even although no positive benefit in increased illuminative power were attainable by its use. The only expense to speak of in testing its utility will be the cost of license from the patentees, which will be as nothing when placed in competition with the alleged advantages. We feel more assured than ever, then, that the day is

at hand when our metropolitan gas will indeed be so pure that it will find ready and extensive access to our private dwellings, and that the only points to be further urged to that desirable end will relate to the requisite general arrangements as to fittings and as to ventilation,—both of these points of great practical importance, to which we have repeatedly drawn attention.—*London Builder.*

IRON AND ZINC.

ANTHRACITE IRON—CHARACTER AND CONSTITUTION OF ANTHRACITE—AMOUNT OF BLAST REQUIRED FOR ITS COMBUSTION.

In the prosecution of the manufacture of iron, with any kind of fuel whatever, it is desirable to know in advance, at least within approximate limits, what amount of mechanical power will suffice to administer in the most advantageous manner, the requisite quantity of air to the furnace.

Two circumstances will chiefly determine this question.

First, the weight of oxygen required from the air, for the complete combustion of the fuel to be used in a given time.

Secondly, the pressure under which it is to be delivered to the furnace.

In the case of anthracite, the weight of oxygen will, in general, be easily computed, since it contains little or no other combustible than carbon, and since the quantity of this is pretty well ascertained, for the various coal fields which supply iron furnaces.

Analysis of single, well selected specimens of anthracite, must not, however, be too implicitly relied on. There is, inevitably, intermixed with the coal, more or less slaty matter, or coal of a semi-combustible character, which allows it to pass almost unchanged through the blast furnace. This, as well as the earthy residuum of the coal itself, is to be deducted, together with the volatile matter, before assigning the quantity of carbon which is to undergo combustion in the blast furnace. It will not be far from the truth to deduct for volatile matter, ashes and unconsumed coal or slate, 15 per cent. of all the anthracite which is put in at the tunnel head, leaving 85 per cent. for the carbon consumed. Some varieties will doubtless give a small per cent. more than this quantity, while others will yield less. To make the computation more nearly accurate, a large quantity of the particular anthracite used, should be analyzed, and the quantity of earthy matter, after incineration, be carefully weighed. If, in use in a furnace, the amount of unburnt slate and coal which comes through in a given time, should be ascertained.

The results obtained by calculations of the kind here indicated will of course give only approximations. The ore will furnish no inconsiderable quantity of oxygen. Some atmospheric air will escape combustion; and much of the gas escaping at the tunnel head is not carbonic acid, but carbonic oxide and carburetted hydrogen.

To aid in forming estimates of the volume of air required in anthracite furnaces, the following analyses of that material, from different parts of the coal regions, may be consulted.

Though not immediately connected with our present investigations, yet for the purpose of ready comparison, it has been deemed proper to add, in a subsequent table, some analyses of our free-burning bituminous coals.

The first nine of the following analyses (Table III.), give a fair average of the coal at the eastern extremity of the middle coal field, and show that the volatile matter is 6.91, the fixed carbon 88.744, and the ashes, 4.346 per cent. The mean specific gravity of these nine varieties is 1.587. The second nine give the character of the north-western termination of the southern anthracite field. The mean percentage of volatile matter is here 8.066, of carbon 87.36, and of ashes 4.574.

TABLE III.—*View of the composition of some of the Anthracite Coals of Pennsylvania, as determined by the writer's analyses.*

Locality of Coal.	Sp. Gr.	Vol. Matter.	Carbon.	Ashes.
1. Summit Co's Lands, head of Beaver Creek....	1.560	6.42	92.30	1.28
2. do. 2d bed	1.594	4.31	91.69	4.00
3. do. 3d do.	1.613	7.51	87.48	5.01
4. do. 4th do.	1.630	9.60	85.34	5.06
5. Stevenson's Bluff, west of Beaver Meadow ...	1.613	9.23	86.06	3.71
6. Buck Mountain	1.559	5.90	91.02	3.08
7. Sugar Loaf Co., 1st specimen	1.591	6.98	88.19	4.83
8. do. 2d bed....................................	1.574	5.36	85.91	8.73
9. do. same bed, but further down the slope.....	1.550	6.87	90.71	2.42
10. Lyken's Valley, 1st sample....................	1.391	7.60	87.95	4.45
11. do. 2d sample	1.404	5.95	89.30	4.75
12. do. 3d do.	1.416	10.00	85.70	4.30
13. do. 4th do.	1.374	4.60	88.70	6.70
14. do. 5th do.	1.376	3.35	87.75	8.90
15. do. 6th do.	1.395	8.30	88.65	3.05
16. do. 7th do.	1.382	8.65	87.20	4.15
17. do. 8th do.	1.398	11.85	84.00	4.15
18. do. 9th do.	1.378	7.30	87.00	5.70
19. Mauch Chunk, Summit Mines....................	1.590	7.90	87.10	5.00
20. Room Run Mines....................................	1.604	6.15	87.20	6.65
21. Pottsville	1.569	6.71	86.54	6.75

The amount of these several ingredients in the last class of coals, is nearly identical with those of the anthracite used by Mr. Crane, in his iron works in South Wales.

TABLE IV.—*View of some of the "free-burning" Bituminous Coals of Pennsylvania, suitable to be used in blast furnaces, either with or without coking.*

Locality.	Sp. Gr.	Vol. Matter.	Carbon.	Ashes.
1. Savage Mountain Coal trough Somerset County	1.319	20.2	75.75	4.05
2. do. 2d bed	1.321	19.9	69.10	11.00
3. do. 3d do.	1.343	21.8	69.90	8.10
4. do. 4th do.	1.362	19.8	68.54	11.66
5. do. 5th do.	1.368	18.3	71.50	10.20
6. do. 6th do.	1.370	18.8	70.70	10.50
7. do. 7th do.	1.386	20.1	68.46	11.44
8. do. 8th do.	1.388	19.5	68.44	12.06
9. do. 9th do.	1.490	18.7	68.56	12.79
10. do. 10th do.	1.491	17.6	66.36	16.04
11. do. Maryland Mining Co. (Maryland)	1.487	15.62	68.56	15.82
12. do. George Creek, at Lonakoning (Maryland).	1.346	16.03	70.75	13.22
13. Carbon Creek, Bradford Co. (Pa.) 1st sample..	1.515	15.00	62.60	22.40
14. do. 2d sample	1.448	17.40	70.00	12.60
15. do. 3d ditto	1.465	19.10	63.90	17.00
16. do. 2d bed, 1st sample..........................	1.377	20.50	68.10	11.40
17. do. do. 2d do:	1.378	19.20	65.50	15.30
18. do. do. 3d do.	1.349	19.30	74.97	5.73
19. do. 3d bed, 1st sample..........................	1.383	17.90	69.00	13.10
20. do. do. 2d do	1.400	18.90	68.57	12.53
21. Lick Run, Lycoming County (Pa.) Diamond ply	1.320	19.80	75.20	5.00
22. Quinn's Run, Lycoming County	1.372	18.80	74.40	6.80
23. Broad Top Mountain, Bedford Co. (Pa.)......	1.301	15.90	77.60	6.50

It appears from Table I. that the number of tons of anthracite supplied per week to seven furnaces, viz., Roaring Creek, Phœnixville, Danville, Crane, Columbia, Montour and Stanhope, is 501.3; and as these furnaces make 310.5 tons of pig metal per week, and demand, on an average, 4.5 cwt. of anthracite to each ton of pig for heating their blast, their total weekly consumption will be 571.16 tons. Hence the anthracite demanded for both smelting and heating blast is $\frac{571.16}{310.5} = 1.84$ tons = 1 ton 16 cwt. 3 qrs. 5.6 lbs. to the ton of pig metal produced. If this anthracite were pure carbon and were completely converted into carbonic acid, the weight of oxygen required for that purpose would be $\frac{8}{3} \times 1.84 = 4.906$ tons; but if we admit that the mean of the two

sets of analyses above given represents the average quantity of carbon in Pennsylvania anthracite, viz., 88 per cent., then the quantity of oxygen will be but $\frac{88}{100} \times 4.906 = 4.317$ tons. As the oxygen is to be supplied from the atmosphere, of which the composition (omitting moisture and impurities) is 28 parts by weight of nitrogen to 8 of oxygen, the total quantity of *air* for one ton of pig will be $\frac{36}{8} \times 4.317 = 19{,}426$ tons; which, at 13.22 cubic feet to the pound avoirdupois, will be equal to 572,255 cubic feet. Hence it is easy to calculate what number of cubic feet of air should be delivered to the furnace and heating ovens, when we have determined how many tons of iron can be made per day. Thus, suppose the furnace to make 7 tons per day, the time for making one ton will be $1440 \div 7 = 205.7$ minutes, and the number of cubic feet of air *required to pass the nozzles* in one minute will be $\frac{572{,}255}{205.7} = 2782$.

The seven furnaces above named receive 22,569 cubic feet of air into their blowing cylinders per minute, and the aggregate area of their boshes is 512.67 square feet. The anthracite which they use will not probably yield over 85 per cent. of pure carbon, after deducting that which escapes combustion and comes out with the cinder, together with the slate unavoidably intermixed, and the dust which is projected out at the trunnel head. The quantity of anthracite which makes one ton of pig is, as above, 1.84 tons.

The *time* required for the seven furnaces to make one ton of pig is $\frac{17640}{512.67} = 34.4$ minutes. The weight of carbon burnt in that time is $.85 \times 1.84 = 1.564$ tons; and this will require 2.66 times its weight of oxygen to form carbonic acid, or 4.16 tons. This quantity of oxygen will be contained in $\frac{36}{8} \times 4.16 = 18.72$ tons of air; which, at 29,612.^{8} cubic feet to the ton, gives 554,351.^{6} cubic feet of air to make one ton of pig; and as this takes 34.4 minutes, the air required to be burnt at all the furnaces per minute, is $554{,}351.^6 \div 34.4 = 16{,}149$ cubic feet. Deducting this from 22,569, the quantity derived from observations on the movements of the blowing pistons, we have a surplus of 6,454 cubic feet, or 28.4 per cent. of the whole, either not completely expelled through the eduction valves, or allowed to escape at the safety valves, joints and tuyeres, or remaining unburnt in the furnace and heating ovens. With regard to the latter, it may be safely asserted that they do not consume more than one half of the oxygen which passes through their grates.

In general, according to a preceding deduction, let the number of tons of iron which a furnace can make per day be represented by $\frac{B}{12.25}$; B being the area of cross section of such furnace at the boshes. Then will the time, in minutes, of making one ton be $\frac{12.25}{B} \times 1440 = \frac{17640}{B}$. Let the proportion of carbon in 100 parts of the anthracite used be $\frac{c}{100}$, and the weight of anthracite, in tons, required to smelt one ton of pig be a; then the quantity of *carbon* consumed in making a ton of iron will be $\frac{ca}{100}$, and the weight of *air*, in tons, required for its combustion into carbonic acid, $\frac{16}{6} \times \frac{36}{8} \times \frac{ca}{100} = 0.12ca$. The conversion of this expression of the *weight* of air into *cubic feet*, is easily affected, since 13.22 cubic feet weigh one pound avoirdupois, and the ton of air consequently contains $2240 \times 13.22 = 29{,}612.^8$ cubic feet. Hence the number of cubic feet of air used in making a ton of pig metal will be represented by $29{,}612.^8 \times 0.12ca = 3553.5ca$. Dividing this bulk of air by the above expression, representing the time in minutes required to make one ton of pig, we get $\frac{3553.5ca}{\frac{17640}{B}} = .2014caB =$ the number of cubic feet of air required per minute by the furnace and heating ovens. In other words, *multiply together the area of boshes in square feet,—the weight of anthracite in tons used per ton of pig, produced,—the number representing the percentage of carbon in the anthracite and the decimal* 0.2014, *and the product will give the number of cubic feet of air, before compression, which must enter the furnace and heating ovens per minute.* If we take into account the quantity of oxygen contained in the ore, it might be supposed that a large deduction

would be allowable from the bulk of air given by this formula; but the quantity of oxygen which does not undergo combustion will account for the fact, that even a greater quantity than that given by calculation is actually injected into the fires.

It will of course be understood, that all the above deductions are to be regarded as approximations only, such as the present working of the several establishments enables us to make. To give exact data for calculations of this nature, they ought to be furnished with more correct instruments for observing and recording the several items which enter into the computation. The waste space above and below the piston should be known. The number of movements of piston per day should be marked by a self-registering apparatus; the pressure should be marked by an inverted syphon gauge of large-sized glass tube: the two limbs being accurately of the same diameter, and connected at bottom by a section of diminished and almost capillary size, thus preventing rapid and violent oscillations, which always interfere with accurate experiments. Where works are situated at considerable elevations, the mean barometric pressure should be known,—and if the season of making observations do not extend through the year, the temperature and dew point of the air at the times of observing, should be reduced to that of the annual mean. It would be desirable to know, in all cases, the quantity of matter volatile at a white heat, both in the ore, the coal, and the limestone; as well as the fixed matter, other than iron, in the ore, the ashes of the coal, and the lime or other materials after calcination, in the limestone. The weight of cinder as well as of pig metal, which is drawn from the furnace, should be ascertained, if we would form a just and intelligent estimate of what is going on within. Due economy of moving power is every where more or less important, and hence the accuracy of workmanship in blowing apparatus can hardly be overestimated. Where anthracite is transported to a distance for supplying this force, the best means of applying its heating power should be well understood. Great economy has within a few years been obtained by an attention to philosophical principles, in generating and using steam, whether obtained from wood or from mineral fuel; and since the most wasteful practices often exist in connection with this part of an iron establishment, a careful attention should be given to ascertain the quantity of water by weight which goes into the boiler, per week, as well as its temperature and the weight and quality of the anthracite with which the evaporation is effected.—*Walter R. Johnson.*

MANUFACTURE OF MALLEABLE IRON.—BESSEMER'S INVENTION.

Works are in preparation, we learn, to test this process upon an extensive scale. This is the true course to determine its value. Meantime we lay before our readers an article on the subject by the inventor, Mr. Bessemer—which appeared in the Sept. No. of the London Civil Engineer and Architect's Journal.

"The manufacture of iron in this country has attained such an important position that any improvement in this branch of our national industry cannot fail to be a source of general interest, and will, I trust, be a sufficient excuse for the present brief, and, I fear, imperfect paper. I may mention that for the last two years my attention has been almost exclusively directed to the manufacture of malleable iron and steel, in which, however, I had made but little progress until within the last eight or nine months. The constant pulling down and re-building of furnaces, and the toil of daily experiments with large charges of iron, had already begun to exhaust my stock of patience; but the numerous observations I had made during this very unpromising period, all tended to confirm an entirely new view of the subject, which at that time forced itself upon my attention—viz: that I could produce a much more intense heat without any furnace or fuel than could be obtained by either of the modifications I had used, and consequently that I should not only avoid

the injurious action of mineral fuel on the iron under operation, but that I should at the same time avoid also the expense of the fuel. Some preliminary trials were made on from 10 lbs. to 20 lbs. of iron, and, although the process was fraught with considerable difficulty, it exhibited such unmistakable signs of success, as to induce me at once to put up an apparatus capable of converting about 7 cwt. of crude pig-iron into malleable iron in 30 minutes. With such masses of metal to operate on, the difficulties which beset the small laboratory experiments of 10 lbs., entirely disappeared. On this new field of inquiry I set out with the assumption that crude iron contains about 5 per cent. of carbon; that carbon cannot exist at a white heat in the presence of oxygen without uniting therewith and producing combustion; that such combustion would proceed with a rapidity dependent on the amount of surface of carbon exposed; and, lastly, that the temperature which the metal would acquire would be also dependent on the rapidity with which the oxygen and carbon were made to combine, and consequently that it was only necessary to bring the oxygen and carbon together in such a manner that a vast surface should be exposed to their mutual action, in order to produce a temperature hitherto unattainable in our largest furnaces. With a view of testing practically this theory, I constructed a cylindrical vessel of three feet in diameter and five feet in height, somewhat like an ordinary cupola furnace, the interior of which is lined with fire bricks, and at about two inches from the bottom of it I inserted five tuyere pipes, the nozzles of which are formed of well-burnt fire clay, the orifice of each tuyere being about three-eighths of an inch in diameter; they are so put into the brick lining (from the outer side) as to admit of their removal and renewal in a few minutes when they are worn out. At one side of the vessel, about half way up from the bottom, there is a hole made for running in the crude metal, and on the opposite side there is a tap-hole stopped with loam, by means of which the iron is run out at the end of the process. In practice, this converting vessel may be made of any convenient size, but I prefer that it should not hold less than one, nor more than five tons of fluid iron, at each charge. The vessel should be placed so near to the discharge hole of the blast furnace as to allow the iron to flow along the gutter into it; a small blast cylinder will be required, capable of compressing air to about 8 lbs. or 10 lbs. to the square inch. A communication having been made between it and the tuyeres before named, the converting vessel will be in a condition to commence work; it will, however, on the occasion of its first being used after relining with fire-bricks, be necessary to make a fire in the interior with a few baskets of coke, so as to dry the brick-work and heat up the vessel for the first operation, after which the fire is to be all carefully raked out at the tapping hole, which is again to be made good with loam. The vessel will then be in readiness to commence work, and may be so continued without any use of fuel, until the brick lining in the course of time becomes worn away and a new lining is required. I have before mentioned that the tuyeres are situated nearly close to the bottom of the vessel; the fluid metal will therefore rise some 18 inches or 2 feet above them. It is therefore necessary, in order to prevent the metal from entering the tuyere holes, to turn on the blast before allowing the fluid crude iron to run into the vessel from the blast furnace. This having been done, and the fluid iron run in, a rapid boiling up of the metal will be heard going on within the vessel, the metal being tossed violently about and dashed from side to side, shaking the vessel by the force with which it moves. From the throat of the converting vessel, flame will then immediately issue, accompanied by a few bright sparks. This state of things will continue for about fifteen or twenty minutes, during which time the oxygen in the atmospheric air combines with the carbon contained in the iron, producing carbonic acid gas, and at the same time evolving a powerful heat. Now, as this heat is generated in the interior of, and is diffused in innumerable fiery bubbles through the whole fluid mass, the metal absorbs the greater part of it, and its temperature becomes immensely increased, and by the expiration of the fifteen or twenty minutes before

named, that part of the carbon which appears mechanically mixed and diffused through the crude iron has been entirely consumed. The temperature, however, is so high that the chemically combined carbon now begins to separate from the metal, as is at once indicated by an immense increase in the volume of flame rushing out of the throat of the vessel. The metal in the vessel now rises several inches above its natural level, and a light, frothy slag makes its appearance, and is thrown out in large foamlike masses. This violent eruption of cinder generally lasts about five or six minutes, when all further appearance of it ceases, a steady and powerful flame replacing the shower of sparks and cinder which always accompanies the boil. The rapid union of carbon and oxygen which thus takes place adds still further to the temperature of the metal, while the diminished quantity of carbon present allows a part of the oxygen to combine with the iron, which undergoes combustion and is converted into an oxide. At the excessive temperature that the metal has now acquired, the oxide as soon as formed undergoes fusion, and forms a powerful solvent of those earthy bases that are associated with the iron. The violent ebullition which is going on mixes most intimately the scoria and metal, every part of which is thus brought in contact with the fluid oxide, which will thus wash and cleanse the metal most thoroughly from the silica and other earthy bases which are combined with the crude iron, while the sulphur and other volatile matters which cling so tenaciously to iron at ordinary temperatures are driven off, the sulphur combining with the oxygen and forming sulphurous acid gas. The loss in weight of crude iron during its conversion into an ingot of malleable iron was found on a mean of four experiments to be 12½ per cent., to which will have to be added the loss of metal in the finishing rolls. This will make the entire loss probably not less than 18 per cent., instead of about 28 per cent., which is the loss on the present system. A large portion of this metal is, however, recoverable, by treating with carbonaceous gases the rich oxide thrown out of the furnace during the boil. The slags are found to contain innumerable small grains of metallic iron, which are mechanically held in suspension in the slags, and may be easily recovered. I have before mentioned that after the boil has taken place a steady and powerful flame succeeds, which continues without any change for about ten minutes, when it rapidly falls off. As soon as this diminution of flame is apparent, the workmen will know that the process is completed, and that the crude iron has been converted into pure malleable iron, which he will form into ingots of any suitable size and shape by simply opening the tap-hole of the converting vessel, and allowing the fluid malleable iron to flow into the iron ingot moulds placed there to receive it. The masses of iron thus formed will be perfectly free from any admixture of cinder, oxide, or other extraneous matters, and will be far more pure and in a forwarder state of manufacture than a pile formed of ordinary puddle bars. And thus it will be seen, that by a single process, requiring no manipulation of particular skill, and with only one workman, from three to five tons of crude iron passes into the condition of several piles of malleable iron in from thirty to thirty-five minutes, with the expenditure of about one-third part the blast now used in a finery furnace with an equal charge of iron, and with the consumption of no other fuel than is contained in the crude iron. To those who are best acquainted with the nature of fluid iron, it may be a matter of surprise that a blast of cold air forced into melted crude iron, is capable of raising its temperature to such a degree as to retain it in a perfect state of fluidity after it has lost all its carbon, and is in the condition of malleable iron, which in the highest heat of our forges only becomes softened into a pasty mass. But such is the excessive temperature that I am enabled to arrive at with a properly shaped converting vessel and a judicious distribution of the blast, that I am enabled not only to obtain the fluidity of the metal, but to create so much surplus heat as to re-melt the crop ends, ingot runners, and other scrap that is made throughout the process, and thus bring them without labor or fuel into ingots of quality equal to the rest of the charge of new metal. For this purpose a small arched chamber is formed im-

mediately over the throat of the converting vessel, somewhat like the tunnel head of the blast furnace. This chamber has two or more openings on the sides of it, and its floor is made to slope downwards to the throat. As soon as a charge of fluid malleable iron has been drawn off from the connecting vessel, the workmen will take the scrap intended to be worked into the next charge, and proceed to introduce the several pieces into the small chamber, piling them up around the opening of the throat. When this is done he will run his charge of crude metal, and again commence the process. By the time the boil commences the bar ends or other scrap will have acquired a white heat, and by the time it is over most of them will have been melted and run down into the charge. Any pieces, however, that remain may then be pushed in by the workman, and by the time the process is completed they will all be melted, and ultimately combined with the rest of the charge, so that all scrap iron, whether cast or malleable, may thus be used up without any loss or expense. As an example of the power that iron has of generating heat in this process, I may mention a circumstance that occurred to me during my experiments; I was trying how small a set of tuyeres could be used; but the size chosen proved to be too small, and after blowing into the metal for one hour and three-quarters I could not get up heat enough with them to bring on the boil. The experiment was therefore discontinued, during which time two-thirds of the metal solidified and the rest was run off. A larger set of tuyere pipes were then put in, and a fresh charge of fluid iron run into the vessel, which had the effect of entirely re-melting the former charge, and when the whole was tapped out, it exhibited as usual that intense and dazzling brightness peculiar to the electric light.

"To persons conversant with the manufacture of iron it will be at once apparent that the ingots of malleable metal which I have described will have no hard or steely parts, such as is found in puddle iron, requiring a great amount of rolling to blend them with the general mass, nor will such ingots require an excess of rolling to expel cinder from the interior of the mass, since none can exist in the ingot, which is pure and perfectly homogeneous throughout, and hence requires only as much rolling as is necessary for the development of fibre; it therefore follows that, instead of forming a merchant bar or rail by the union of a number of separate pieces welded together, it will be far more simple and less expensive to make several bars or rails from a single ingot; doubtless this would have been done long ago, had not the whole process been limited by the size of the ball which the puddler could make.

"The facility which the new process affords of making large masses, will enable the manufacturer to produce bars that on the old mode of working it was impossible to obtain; while, at the same time, it admits of the use of some powerful machinery whereby a great deal of labor will be saved, and the process be greatly expedited. I merely mention this fact in passing, as it is not my intention at the present moment to enter upon any details of the improvements I have made in this department of the manufacture, because the patents which I have obtained for them are not yet specified. Before, however, dismissing this branch of the subject, I wish to call the attention of the meeting to some of the peculiarities which distinguish cast steel from all other forms of iron, namely, the perfect homogeneous character of the metal, the entire absence of sand cracks or flaws, and its greater cohesive force and elasticity as compared with the blister steel from which it is made,—qualities which it derives solely from its fusion and formation into ingots, all of which properties malleable iron acquires in like manner by its fusion and formation into ingots in the new process. Nor must it be forgotten that no amount of rolling will give to blister steel (although formed of rolled bars) the same homogeneous character that cast steel acquires by a mere extension of the ingot to some 10 or 12 times its original length.

"One of the most important facts connected with the new system of manufacturing malleable iron is, that all the iron so produced will be of that quality known as charcoal iron, not that any charcoal is used in its manufac-

ture, but because the whole of the processes following the smelting of it are conducted entirely without contact with, or the use of, any mineral fuel; the iron resulting therefrom, will, in consequence, be perfectly free from those injurious properties which that description of fuel never fails to impart to iron that is brought under its influence. At the same time this system of manufacturing malleable iron offers extraordinary facility for making large shafts, cranks, and other heavy masses; it will be obvious that any weight of metal that can be founded in ordinary cast iron by the means at present at our disposal may also be founded in molten malleable iron, and be wrought into the forms and shapes required, provided that we increase the size and power of our machinery to the extent necessary to deal with large masses of metal. A few minutes' such reflection will show the great anomaly presented by the scale on which the consecutive processes of iron-making are at present carried on. The little furnaces originally used for smelting ore have from time to time increased in size, until they have assumed colossal proportions, and are made to operate on 200 or 300 tons of material at a time, giving out 10 tons of fluid metal at a single run. The manufacturer has thus gone on increasing the size of his smelting furnaces, and adapting to their use the blast apparatus of the requisite proportions, and has, by this means, lessened the cost of production in every way; his large furnaces require a great deal less labor to produce a given weight of iron than would have been required to produce it with a dozen furnaces, and in like manner he diminishes his cost of fuel blast and repairs, while he insures a uniformity in the result that could never have been arrived at by the use of a multiplicity of small furnaces. While the manufacturer has shown himself fully alive to these advantages, he has still been under the necessity of leaving the succeeding operations to be carried out on a scale wholly at variance with the principles he has found so advantageous in the smelting department. It is true that hitherto no better method was known than the puddling process, in which from 400 to 500 weight of iron is all that can be operated upon at a time, and even this small quantity is divided into homœopathic doses of some 70 lbs. or 80 lbs., each of which is moulded and fashioned by human labor, carefully watched and tended in the furnace, and removed therefrom, one at a time, to be carefully manipulated and squeezed into form. When we consider the vast extent of manufacture, and the gigantic scale on which the early stages of progress are conducted it is astonishing that no effort should have been made to raise the after processes somewhat nearer to a level commensurate with the preceding ones, and thus rescue the trade from the trammels which have so long surrounded it.

"Before concluding these remarks I beg to call your attention to an important fact connected with the new process, which affords peculiar facilities for the manufacture of cast steel.

"At the stage of the process immediately following the boil, the whole of the crude iron has passed into the condition of cast steel of ordinary quality; by the continuation of the process the steel so produced gradually loses its small remaining portion of carbon, and passes successively from hard to soft steel, and from soft steel to steely iron, and eventually to very soft iron; hence at a certain period of the process any quality of metal may be obtained; there is one in particular, which by way of distinction I call semi-steel, being in hardness about midway between ordinary cast steel and soft malleable iron. This metal possesses the advantage of much greater tensile strength than soft iron; it is also more elastic, and does not readily take a permanent set, while it is much harder, and is not worn or indented so easy as soft iron; at the same time it is not so brittle or hard to work as ordinary cast steel. These qualities render it eminently well adapted to purposes where lightness and strength are specially required, or where there is much wear, as in the case of railway bars, which from their softness and lamellar texture soon become destroyed. The cost of the semi-steel will be a fraction less than iron, because the loss of metal that takes place by oxidation in the converting vessel is about

2½ per cent. less than it is with iron; but, as it is a little more difficult to roll, its cost per ton may fairly be considered to be the same as iron; but, as its tensile strength is some 30 or 40 per cent. greater than bar iron, it follows that for most purposes a much less weight of metal may be used, so that taken in that way the semi-steel will form a much cheaper metal than any we are at present acquainted with.

"In conclusion, allow me to observe that the facts which I have had the honor of bringing before the meeting have not been elicited from mere laboratory experiments, but have been the result of working on a scale nearly twice as great as is pursued in our largest iron works, the experimental apparatus doing 7 cwt. in 30 minutes, while the ordinary puddling furnace makes only 4½ cwt. in two hours, which is made into six separate balls, while the ingots or blooms are smooth, even prisms, 10 inches square, by 30 inches in length, weighing about equal to ten ordinary puddle balls."

Mr. Bessemer's process has, since the reading of his paper before the British Association, been put to a severe practical test, with the most successful result, at Baxter house, St. Pancras road, in the presence of several iron masters, practical engineers, and scientific men resident in the metropolis.

Men like the two Rennies, Nasmyth, and others of minor note, but of great experience as engineers and iron manufacturers, have pronounced emphatically and without qualification in its favor, whilst some, including Nasmyth, declare themselves unable to foresee the whole of the advantageous results, calculated to spring from its discovery, not to this country alone, but wherever else it may be brought into use.

In conducting the demonstration, 6 cwt. 3 qrs. 18 lbs. of molten iron from a furnace was poured into the fire-brick vessel, already described, at twelve minutes past one o'clock, the blast having been applied at a pressure about 8 lbs. per square inch, and continued until twenty-seven minutes past one. The mass of metal began to boil up, and the cinders and other impurities were extruded from the top of the vessel by two apertures provided for the purpose. Showers of brilliant sparks were thrown off during this process, which lasted several minutes; and as the object was to produce a mass of cast steel, rather than continue the process to the extent necessary for making pure iron free from carbon, the vessel was tapped at thirty-six minutes past one and the contents drawn off. Small specimen ingots being first taken, the general mass was run into an ingeniously contrived mould concealed in the floor in front of the apparatus, and, after remaining there a few minutes, cooling down, it was raised out of the mould in a red-hot state by an hydraulic ram, and placed upon a weighing machine. The ingot thus produced, with the two specimen ingots, weighed 6 cwt. Without the aid of fuel, this mass of material was converted in twenty-four minutes from crude cast iron, as it comes from the blast furnace, into steel of fine quality.

The experiment was unanimously pronounced by the company to be perfectly satisfactory. It is a peculiar and important feature in the process, that by continuing the boiling a few minutes longer, the whole of the carbon still remaining in the mass of metal, and which gives to it the character known as steel, would have been drawn off, and a pure mass of crystaline iron would have been the result.

To the above we add the following remarks by C. Sanderson, of Sheffield, which appeared in a recent number of the *London Mechanics' Magazine*:—

The metallurgical world has been paralyzed not only by the statement set forth at the meeting of the British Association, at Cheltenham, but by the details given in the *Times* of a trial made in London to exhibit Mr. Bessemer's process for producing malleable iron, fine steel, or any mixture of the two which might be required in the arts or by engineers, from crude iron.

The public is justified in receiving the statements made, because it seems impossible to doubt their accuracy. The invention is momentous, involving immense interests, both in the steel and iron trade. It has, like a meteor

shot across the beaten path of science, and dazzled us all by its apparent brilliancy. Having had some experience in the manufacture of both iron and steel, I propose to give the result of such experience, as well as my opinion of this novel mode of manufacture.

Mr. Bessemer runs crude fluid iron into a small cupola-formed vessel: about 7 cwt. of metal only has hitherto been operated upon, but he can as easily act upon five tons. A blast issuing through five tuyeres is driven into the metal at 8 lbs. or 10 lbs. pressure; and the effect obtained is, that the oxygen of the blast, uniting with the carbon, produces carbonic acid or carbonic oxide gas, which gives out a certain amount of heat. This operation goes on as long as there is carbon enough left to unite with the oxygen to produce the gas, and as the supply of carbon becomes reduced, so the ebullition of the metal, caused by the gas struggling to escape, becomes less active, and in the end entirely ceases.

When the agitation of the metal subsides, the contents must then be tapped out, or, it is said, if the iron be allowed to remain a little longer under the action of the blast, then a spongy mass of malleable iron is obtained.

The statement publicly made is that "In thirty minutes, by the foregoing process, Mr. Bessemer converts 7 cwt. of crude metal into ingots of malleable iron or steel of any size, and fit for the various manipulations ordinarily employed." He does away with puddling, hammering, rolling, and all the subsequent operations now in daily use at our iron works. He states that fine steel is produced for the engineer, and for general manufactures, and that iron so produced is equal to Swedish or Russian, now selling at from £20 to £30.

These form the leading features and pretensions of the new process, and if so desirable a result could be obtained, truly the invention would deservedly rank amongst the first, if not the very first, of the age.

I have very carefully examined those results which might be expected from an operation like the one before us, and I cannot agree with the statements made to the public by the inventor, or by those who have seen and supported both his theory and practice.

I freely admit that a *decarbonized cast iron* is obtained—that such iron is bright, white, and crystalline; but *I do not believe* that such metal will admit of being either *drawn under a hammer or rolled to a bar*. I cannot admit such metal into the category of cast steel, for it cannot, in my opinion, fulfil its requirements; it will not make a boring tool, or a cutter—a tap, or a die; it cannot be fashioned by the workman's hammer, or made into a needle, or cut into a file; in fine, I am compelled to give an opinion that it is a metal which cannot assume the commercial value of steel.

At this moment, when Mr. Bessemer's process is receiving so much of the metallurgical world's attention, particularly from those whose high attainments are generally acknowledged, it may appear somewhat presumptuous to find one strong dissentient voice; yet, from the many and very careful experiments I have made, I cannot agree with a too commonly accepted opinion—that presuming cast iron to contain 5 per cent. of carbon, and steel 1 per cent. if you deprive the crude iron of 4 per cent. of its carbon, it necessarily becomes steel. This is not the case. Mr. Bessemer's product is a decarbonized metal; the larger crystals are more decarbonized than the smaller ones, and a good lens will show that the mass is made up of small bright atoms, which are the particles least affected by the operation. The result is a metal not capable of being drawn under a hammer, or rolled to a bar; and whilst I venture to state that the process will not produce steel fit for any useful purpose, I must also add it will not produce a malleable iron suited to our wants.

I feel assured that my practical knowledge has not led me wrong in making these bold statements, which are so opposed to the generally conceived opinion. I trust they will be received in the spirit which has dictated them—not to undervalue Mr. Bessemer's exertions—but to thank him for his "mite" to that general stock of knowledge in the metallurgical art, which has raised England to the elevated position she now enjoys.

Another account states:

The metal experimented upon was No. 2 Blaenavon coal blast, a quantity of which was melted in the common cupola, and from thence run into the refining furnace, the blast having been just previously turned on, and which was kept at a pressure of nine pounds to the inch. In a very short time, viz., eight minutes, the stream of cold air thus passed through the fluid metal caused it to commence boiling; in ten minutes more it was boiling furiously, throwing off quantities of scoria, with a slight explosion like the eruption of a volcano. In twenty-three minutes from the first, the flame emitted showed the metal to be of a white heat, and in twenty-six minutes, the whole of the carbon was consumed, as was immediately perceptible to the eye and ear, the flame and noise having ceased in a moment. The metal was then run out; but, owing to a slight accident, it was impossible to ascertain the loss by the process. The produce was, of course, the subject of much curiosity, this being, according to Mr. Bessemer, malleable iron, ready for rolling into any desired form of rail, bar, etc. There was a good deal of difference of opinion among those present as to the truth of this; some thinking that the experiment had resulted perfectly, and others, and more cautious and practical men, thinking that the result was only a superior description of refined metal. From the fracture the writer is inclined to take this view himself; but even then a very great step had been made, as to make refined metal without the use of any fuel whatever, and consequently at a greatly reduced cost, and of immensely improved quality, is a fact of the greatest importance, and may be of immediate use to tin-plate makers, iron wire-makers, etc. Without doubt the invention is most valuable, and will no doubt in time accomplish all that is claimed for it. It was stated on the ground that an eminent firm in Wales had, unknown to the patentee, been making their own experiments, and were so satisfied with the result, that they have taken a license for fourteen years from Mr. Bessemer, paying him £10,000 cash down.

NEW CAST-STEEL PROCESS.

R. A. Brooman, of London (Editor *Mechanics' Magazine*) has secured a patent as agent for a foreign invention for what is called "a new method of manufacturing cast-steel."

The basis of the invention consists in the introduction into crucibles, along with the pieces of wrought or malleable iron, of certain chemicals in which cyanogen is contained. As for example, cyanide of potassium and ferrocyanide of potassium, are to be used in connection with some form of sal-ammoniac. The usual furnaces and melting pots suitable for melting blister steel may be employed. The malleable iron (which may be of any description, such as bar, scrap, blooms, &c.,) is prepared by cutting or breaking it up into small pieces. In a 20-lbs. charge of iron in a crucible are introduced ten ounces of charcoal, six ounces of common table salt, half an ounce of brick dust or oxide of manganese, one ounce of sal-ammoniac, and half an ounce of ferrocyanide of potassium. The pot is then to be covered and introduced into the furnace, and the contents thoroughly melted, the heat being maintained for the space of three hours or thereabouts. The mass is then to be poured off into iron moulds in the ordinary way of pouring cast-steel, and with the usual care required for producing a solid ingot. This may then be rolled into sheets, or hammered and tillted into bars, after the common method. In this process the employment of table salt, manganese, or brick dust is for the formation of scoriæ upon the top of the melted mass, to keep out the air. The proportions of ingredients given may be varied, and some may be omitted altogether, or others substituted. The essentials are the sal-ammoniac, some substance affording cyanogen, and charcoal. Fine cast-steel may be produced with ferrocyanide of potassium and charcoal, also with sal-ammoniac and charcoal. The hardness or brittleness, as well as firmness of grain and degree of malleability, may be varied by altering the proportions of the several ingredients, especially of the charcoal, sal-ammoniac, and cyanogen. No particular char-

acter or qual ty of iron is necessary. Steel, it is stated, can be produced by this process from common English iron equally as well as from the best Swedish.—*Scientific American.*

RAILROAD IRON MANUFACTURE.

The following interesting article on the manufacture of Railroad Iron, by Prof. W. W. Mather, was prepared for the Railroad Record.

The recent improvement in the conversion of iron from the blast furnace into malleable iron by Mr. Bessemer in England, has attracted much attention. If it can be carried out in practice, as it seems practicable, theoretically, it will work a great change in the manufacture of iron, and be beneficial both to the iron master and to the public.

The improvement consists, 1st, in the rapid removal of the carbon of the iron, by means of a current of air forced through the melted metal; and 2d, the subsequent removal of the earthy materials, silicates, etc., combined with the iron after the carbon has been removed, by a prolonged action of the current of air oxidizing a portion of the iron, and this oxide combines with the silica and other materials, and forms slags that separate from the metal, and leave it in a highly refined state. This is what is claimed by the discoverer of this method, and it seems not unreasonable that it can be carried out in practice.

The same result has been attained more slowly, perhaps not as perfectly, at a greatly increased cost by the various methods of refining iron, and by the puddling and boiling processes, and by the various mechanical operations of squeezing, hammering, rolling, etc.

The iron ore linings of the boiling furnaces, and the addition of finery cinder, and of water in the puddling and boiling furnaces, produced a similar effect of removing carbon, by the oxygen of the iron ore and of the water, taking carbon from the iron, causing in both cases the extrication of carbonic acid and carbonic oxide. The iron ore and finery cinder added, increased the quantity of iron and diminished the loss incident to the conversion of the pig iron into malleable metal. The finery processes also, in one case exposing the broken pig metal to a current of air at a high temperature, and in another, exposing the melted pig iron to a blast of coal or of hot air from tweer-pipes directed downwards upon its surface, are methods long followed, and involve the same principle as the improvement recently made, and also the same in principle as the methods in the boiling and puddling furnaces; but the time, labor, expense, and the fuel for these various operations for the conversion of pig iron to malleable iron, were greatly more than by this improvement, if it should prove well in practice.

This method seems a natural result of an application of the principles involved in the various modes of conversion of pig iron into malleable iron heretofore practised, and the only singularity is, that it has not earlier been thought of and used.

This method, if successful, will greatly diminish the cost of conversion, will do away with the necessity of boiling furnaces, will enable the rolling mills to operate on much larger quantities of iron, make much larger masses of metal of uniform quality in single pieces without welding, and will enable the blast furnaces to convert their metal directly into merchant bars or rail bars, if they prefer to do so, and will induct a new era in the railroad iron manufacture.

In all blast furnaces there is a large surplus of heat that can be applied for steam power for rolling the iron, if rolls and suitable machinery be added. The heavy capital necessary for rolling mills for merchant iron, and for rail bars, and the fact that all rolling mill companies in the United States have gone into the iron market for their pig metal at the high market rates, are circumstances that have prevented, in a high degree, the manufacture of rail bars. If iron companies have both their own blast furnaces and their rolling mills, they can make rail bars as cheap as in Wales or Staffordshire, and can give as much credit on bonds as the English or Welsh iron masters. The same amounts now paid in cash for duties, freight, insurance, agencies, and

charges by our railroad companies, if paid to our iron masters having their own blast furnaces and rolling mills, would pay the cost of the production of the *rail bars*, and the railroad bonds now given to English and Welsh iron masters would remain as profit in the hands of our own citizens, would retain the interest money at home, and would be a basis of credit or of discounts in bank, if they needed bank accommodations.

The vast fields of our iron ore and coal deposits, capable of rapid and easy development, await only the enterprise of our citizens, and the application of capital. The recent rapid development of the manufacture of iron with anthracite and bituminous coal in Pennsylvania—with bituminous coal in Maryland—and the dawn of the same in Ohio, have done away with the prejudices of many of our iron masters, who see not only that iron can be made with mineral fuel, but that good iron for foundry uses, for merchant irons, and even for horse-shoe nails can thus be made. Several stone coal furnaces are now in operation in Ohio, and others are building, and the capacity of the iron region of Ohio is not less than for 1000 stone coal furnaces for 2000 years.

The cost of rail bars made of stone coal pig iron by the methods now employed varies from 32 to 38 dollars per ton, where the profits of the pig metal manufacture are not included, but interest on capital, taxes, and wear and repairs are included.

Each railroad company could have its own furnaces and rolling mill for rail bars connected in one establishment for the production of its own rails, or to supply the deterioration of their rails already laid. A railroad of 100 miles in length requires about 10,000 tons of rails to lay the track, and an annual average of 1000 tons annually, to supply the deterioration and wear of the track. Several single roads of the United States of 300 or more miles long, require an annual supply of 8000 or more tons of rails, and are supplied from the markets at $200,000 to $250 000 per annum. With their own mills and furnaces, they could be supplied at half that cost. The investment of $;00,000 in the mills, and furnaces, and land, would in some instances save nearly the whole cost of the investment to the company, in a single year, and in future years make a large saving in the outlay for iron, and could make a large profit for the company, by selling their surplus production at the market price to other railroad companies. W. W. MATHER.

TRURAN AND OTHERS, ON BESSEMER'S PROCESS.

M. Truran, author of "The Iron Manufacture of Great Britain," in a letter to the London *Mechanic's Magazine*, severely criticises Mr. Bessemer's paper, which he read before the British Scientific Association, describing his process for manufacturing malleable iron and steel from crude iron. He asserts that Bessemer is neither correct in his theory nor his conclusions; also, that iron produced by this process neither possesses the qualities of wrought-iron nor steel.

He says:—"The mere removal of a portion of the impurities in the iron by fusion does not, of itself, convert cast into malleable iron; castings with a slight degree of malleability at low temperature, are common in England and in other countries; at high temperatures they lose this quality, are equally brittle with other cast-irons, and are utterly devoid of the welding principle. . . . . The cast steel of excellent quality which it is to produce—cheap as finers' metal—has yet to be made and exhibited in articles of cutlery. A few pieces of refined iron were exhibited at the meeting, but these were no more like bars of iron or steel than chilled cast-iron is like tempered steel."

Mr. J. G. Miner, of Mott Haven, is the author of the following views contributed to the *Scientific American*:—

Having been solicited to give some expression to my views of Mr. Bessemer's method of converting crude metal into steel or wrought iron, it may not be inappropriate to do so through the columns of your valuable journal. Mr. Bessemer furnishes a clear and detailed description of his apparatus,

method of treatment by atmospheric air, informing us of the chemical changes produced, and claims the resulting product to be at the pleasure of the operator, "fine steel, or masses of malleable iron perfectly free from any admixture of cinder, oxide, or other extraneous matters," equal in quality to charcoal iron.

Iron or steel, perfectly free from any admixture of cinder, oxide, or other extraneous matters; in other words, absolutely pure iron, is not the article those engaged in their manufacture should seek to produce.

Let us, for illustration, examine the chemical composition of a few varieties of iron and steel, and ascertain whether Mr. Bessemer's proposition, that the nearer absolute purity we approach in the production of iron, the more useful qualities that iron will be possessed of.

The following table represents the chemical structure of several kinds of iron and steel—viz., No. 1, English gray cast-iron; No. 2, English refined; No. 3, Danemora Swedish; No. 4, German; No. 5, English common steel; No. 6, English best razor steel:—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Iron,	94·63	98·90	98·78	99·87	97·94	93·80
Carbon,	2·60	0·41	0·84	0·09	1·72	1·43
Sulphur,	0·35			trace.		1·00
Phosphorus,	0·39	0·40				
Silicon,	1·53	0·08	0·02	0·03	0·22	0·52
Arsenic,			0·02		0·07	0·93
Antimony,						0·12
Manganese,	0·50	0·04	0·05		0·02	1·92
Copper.			0·07			
Nitrogen,						0·18

Here we find that the English crude iron approaches nearer metallic purity than the best English razor steel; and the Swedish, possessing less purity than English refined iron, yet capable of sustaining over 72,000 pounds to the square inch, while the latter breaks at about 55,000; and the German iron, which is the nearest approach to absolute purity, although possessing fibres, is so soft and weak as to be of less value than either.

For one, I must state that experience has heretofore taught, that the quality of the manufactured iron depends more upon the description of ore and fuel, made use of in its first production, than upon the manner of subsequent treatment. It is in the blast furnace, and not afterwards, that the character of the iron produced is determined. The superior qualities of the Swedish Danemora iron are alone due to the peculiarly fine magnetic ore from which it is manufactured, and not to the manner or method of manufacture. Other districts in Sweden produce iron by the same process, and from a somewhat similar magnetic ore, but their products will not bear comparison with the Danemora in mercantile value. It is to the Danemora iron that Mr. Bessemer refers, as selling in England at thirty pounds sterling per ton, the future sales of which are to be estopped by his invention. There are many cases in which wrought iron contains a larger proportion of impurities than crude iron, and is yet malleable and useful, while cast iron of the same chemical composition will be extremely hard and brittle.

Berzelieus, the celebrated Swedish chemist, informs us that he detected eighteen per cent. of silex in a certain kind of bar iron, and that this iron was still malleable and useful. One-tenth of that amount of silex will make crude iron brittle. The best qualities of bar iron are always found to contain a small amount of impurities. Steel ceases to be hard and strong if we deprive it of the small amount of silicon it contains, or if by repeated heating that silicon becomes oxidized. This is the case with bar iron. Deprive it of all foreign admixtures, it ceases to be strong, tenacious, beautiful iron, and becomes a pale, soft metal, of feeble strength and of doubtful utility. The main difference between crude and malleable bar iron consists in their mechanical, rather than chemical structure. Crude iron is a mixture of impurities and metal, both chemically and mechanically combined, where the atomatic crystals are found in intimate contact with each other, and in which a transformation to an entirely chemical admixture is readily effected. Wrought iron is a mechanical mixture of iron more or less pure, with a mass of homo-

geneous impurities or cinder, the latter filling the spaces between the particles of iron. Iron, in a connected form, and cinder in separate cells, are thus blended in one homogeneous mass. The more this is stretched, either by the hammer or rolls, the more fibrous it becomes, and other circumstances being equal, the strength of the iron will be proportional to the fineness of the fibres.

Mr. Bessemer appears to congratulate himself upon the excessively elevated temperature that he obtains in the latter part of his operation, or after the entire consumption of the contained carbon ; in plain terms, by oxidizing or burning the iron. This oxide, we are told, from the elevated temperature that the metal has acquired as soon as formed, undergoes fusion, and forms a powerful solvent of those earthy bases that are associated with the iron. I am at a loss to comprehend how this is effected ; having heretofore supposed that the melting of such an oxide could not be effected at any temperature in an oxidizing flame, which Mr. Bessemer's clearly is. This immediate melting of the oxide, as described, I cannot deem other than a physical impossibility.

The lower the temperature that crude is worked at, the better will be the quality of the wrought iron produced. Good bar or wrought iron is always fibrous; it loses its fibres neither by heat nor cold. Time may change its aggregate form, but its fibrous quality should always be considered the guarantee of its strength. Fine malleability and fibrous structure can only be given to iron by a tough cinder and manipulation. Mr. Bessemer does not pretend to do this, but rather rests upon the demonstration of his ability to produce a crystalline metal, which, although free from either carbon or cinder, is not known to possess any practical value, and which, leaving his apparatus in the chemical state he alleges it to be in, I have no hesitation in asserting that it cannot be hammered or rolled sufficiently to produce any fibre, and all subsequent improvement of its quality will prove to be extremely difficult.

From the remotest antiquity down to the present day, wrought iron, unsurpassed in quality, has been produced by one manipulation direct from the ore; but the great consumption of fuel and labor attending this method of manufacture, has enabled the blast and puddling furnaces to supersede it, excepting where quality is of greater consideration than quantity. Men of the first scientific attainments have, of late, given expression to the opinion, that the blast and puddling furnaces are soon to be superseded by the introduction of improvements upon the direct method of producing wrought iron.

Such improvements have been made, and can now be seen in operation under my charge at the works of the American Magnetic Iron Co., at this place.

IRON MANUFACTURES AT CINCINNATI.

This has become the most important branch of manufactures in Cincinnati, and prices are as low as at any other point. These details are shown with much care in the annual Statement of the Trade and Commerce of Cincinnati, prepared by Mr. William Smith. The Report thus speaks:

"The products of our machine shops and our foundries are to be found in every city, town, village and hamlet, from Lake Superior on the north to the Gulf of Mexico on the south, and from the Alleghany Mountains on the east to the Indian Territory on the west. The doors of a great number of the houses scattered over this vast territory hang upon Cincinnati hinges, and are made fast at night by Cincinnati locks; the wagon-wheels which roll over its highways are bound with Cincinnati iron; the steam engines and machinery of the mills and factories bear upon them the Cincinnati stamp; and the stoves around which the citizens gather, from the cabin of the squatter to the splendid mansion of the millionnaire, when the frosts and snows of winter weather prevail, stand as witnesses of the extent of Cincinnati industry and Cincinnati skill; and notwithstanding the vast extent of our trade in this department, it is still increasing with extraordinary rapidity, as the statistics we present below clearly demonstrate.

The following table shows the imports of Pig Iron at this place for the last six years:

	tons.
1850-1	16,110
1851-2	22,605
1852-3	30,179
1853-4	41,907
1854-5	26,618
1855-6	41,016

Iron Foundries.—There are thirty-two Iron Foundries in this city and vicinity, many of which have machine shops attached. There are twelve of these establishments where stoves and hollow ware are made exclusively; the remainder are, properly speaking, manufactories of machinery, having foundries attached, where they make their own castings. The average value of the articles manufactured by each of these establishments during the past year, is $116,00, making the aggregate value of $3,712,000. There are employed in these establishments 1,920 hands directly, besides about 800 indirectly. The increase in the business of each establishment this year, as compared with last, ranges from fifteen to one hundred and thirty per cent. averaging forty-eight per cent. This seems almost incredible; but quite a large number of the proprietors inform us that their business was limited only by the capacity of their establishments to manufacture. The greatest increase is in the manufacture of steam engines, railway work, and stoves and hollow ware. The demand from Northern Illinois, Iowa, Wisconsin and Minnesota for these articles is rapidly increasing, and as a general thing, the orders are from three to six weeks ahead.

Immediately connected with, and indeed growing out of this department of the iron business, is pattern-making, which is rapidly increasing. The proprietors of one establishment say, "In 1851 we commenced without any business, and now we have more than we can do; last year the value of the work turned out by us was $15,000.

Rolling Mills.—There are five Iron Rolling Mills in this vicinity, two on this side of the river and three in Kentucky; and, besides these, there are five mills at points above, having their agencies in this city; so that the iron made by ten establishments is sold in this market. The total value of the iron made by these establishments last year was $3,167,000, averaging $316,700 each. The increase in the business ranges from twenty to one hundred and five per cent., averaging forty-three per cent., as compared with the business last year. The demand for Merchant Bar Iron from the whole Northwest is very large, and the increase in the demand the present season is chiefly from that quarter.

IRON REGION OF LAKE SUPERIOR.

Burt Mountain is situated seventeen miles west from the lake, and forms the present terminus of the I. M. R. R. The surface indications of the iron ore at this point are of the first class, of which we procured some fine specimens. It has not yet been opened, yet those who understand such matters think it will pay richly to work it. We did not find all the surface indications, yet what we did find contained but littte jasper, being mostly diamond, granulated and slate ore. The weight of it quite surprised us—we took hold of a piece about eight inches square, and three in thickness, thinking to lift it with one hand, but our fingers slipped off as though it had been oiled, and no attempt was made afterwards to lift any but small pieces. The bed of ore which we found lay within a few feet of the railroad track, and could be loaded on to cars at a very small expense. It will probably be opened as soon as the cars are running to this point; from this point we struck off nearly south to Lake Angelina.

Cleveland Mountain is sixteen miles from the lake, and one mile east of the Burt Mountain. This mine is now actively worked, and sends down daily to the lake from forty to fifty tons of good ore. Mr. D. P. Moore, the foreman of the mining work, informed us they had some two hundred tons of ore ready

for transportation, and were constantly gaining upon the teams that take it away. There are now about thirty men employed at this mine constantly, and additions are expected soon. It would be utterly impossible to give an adequate idea of the immense amount of ore at this point—it lies piled up in huge masses above the surface, and the depth of it cannot be determined, but probably extends farther down than ever will be dug to get it. Indeed, there is now enough upon the surface to last for ages, to say nothing of other localities, to which this is but a commencement. The miners have struck a bed of jasper, where they are now at work, on a level with the road, which will not be very profitable working; yet, this is no drawback at all, for it is thought that below it is as good ore as any obtained, and even if there was none, there is enough above ground, which can be got out cheaper than that. This the company will probably do now, as when the work of mining shall become thoroughly systematized, the cheaper ore can be worked as profitably as the best can now. Yet this is not necessary, as there is an unlimited amount of ore that yields from eighty to ninety per cent. of pure iron. There seems to be no obstacle now in the way of the successful and profitable working of this mine.

Jackson Mountain from the lake is fourteen miles distant, and east from the Cleveland Mountain to the place where the miners are working, two miles. It will be seen at once, that thousands of tons can be prepared with but little labor, when a good face is cleaned off and ready for blasting. From Mr. Zimmerman, the foreman of the mining operations, we learned that the Company have eleven men now at work excavating the ore and preparing it for removal. It may not be amiss to remark here, that the ore is broken up into a convenient size for handling and shipping, at all the mines, before it is taken away. They have now at the mines about five hundred tons ready for transportation. The quantity carried to the lake as yet this season is small, comparatively; but we understand the Company have just received a stock of mules, and will probably commence the transportation of it on a large scale very soon. Where the miners are now excavating, the surface exhibits a thin layer of slaty rock, which, being removed, shows ore of the best quality, except in a few small veins which contain some jasper. The surface indications upon the top of the mountain exhibit a rather large proportion of jasper; yet where the side has been faced down it shows that it is only at the surface; what it may be on penetrating to the heart of the mountain, it is impossible to conjecture.

The *Eureka Mine* is distant from the lake but two and a half miles, and but a short distance from the railway, with which it connects by a side track. Some difficulty has been experienced here in getting out the ore, in consequence of the veins being imbedded in the rock, but the work of excavating has been persevered in, until it now promises well. The ore improves as it progresses downward, and the veins grow wider. The close proximity of this mine to the lake, gives it an advantage over those more distant, as the cost of transportation will be materially lessened. There are many locations within the distance which we passed over that we did not visit. They are not yet opened, and we did not think it proper to describe them until they should be, and their value ascertained. This will probably be done at no distant day.

JOURNAL OF GOLD MINING OPERATIONS.

SHIPMENTS FROM SAN FRANCISCO.

Total Shipments for 1854	$47,333,517
" " 1855	44,080,374
" to Aug. 20th, 1856	31,636,240

QUARTZ MINING IN CALIFORNIA.

This pursuit is rapidly becoming one of the most important branches of industry in the State. The California *Mining Journal*, which is published in

Grass Valley, is very full of important news on this subject. Copies of this monthly newspaper can be seen and obtained of us. On the progress of Quartz mining and the improvements, we learn as follows:—

Quartz.—The present scarcity of water and the uncertainty of prospecting for placer diggings, are now turning the attention of great numbers to quartz. We are pleased to learn from our exchanges, and from private advices from all parts of the State, that every where experienced miners are engaged in prospecting new quartz leads, or in thoroughly examining or testing those already discovered. Millions of dollars have already been spent in this department of mining in the central and southern portions of the State, and when compared with a like amount expended in searching for placer leads, the difference is vastly in favor of quartz. In addition to present gains, the opening up of quartz veins adds vastly more to the future and permanent wealth of the State than do the same efforts expended upon the placers. The latter soon become exhausted, and begin to depreciate in value almost from the very first panful of gravel which is taken out; on the contrary, when a good paying quartz lead is struck, the labor that would be sufficient to exhaust most placer diggings, only adds more and more to the value of a quartz claim, by opening it up at a greater number of points, and thereby enabling the proprietor to place an increased number of hands upon his works. In those counties even where the quartz business is most advanced, but little progress, comparatively, has yet been made in opening up their resources in this particular. In many counties, undoubtedly rich in gold-bearing quartz, scarcely a beginning has been made. Where now our mills are counted by dozens, they will soon number hundreds. These quartz mills are to California what the cotton and wollen mills are to New England.

Recently we have noticed evidences of gratifying and increased attention to this department of mining. The Shasta *Republican* says:—"We are assured that there is not a county in the State more rich than ours in the gold-bearing quartz. On the east side of the Sacramento, at Horsetown, at French Gulf, in the vicinity of Whisky Creek and Shasta, and at various other places, rich quartz has been discovered, none of which, except one lead at French Gulch, has been worked. Capitalists who seek to make investments in quartz-mining, cannot do better than to make a thorough examination of our county."

In Nevada county the business still continues prosperous. The mills in this place are all running except one, and that, a water mill, is stopped for the purpose of putting in a new wheel. The five new mills now in process of erection are rapidly approaching a completion.

The Mount Hope Company (late Rocky Bar) have taken out their old pump and put in a new one of much larger dimensions, which will be abundantly able to keep their mine free of water for a long time to come. Their mill is rapidly approaching its completion. It will probably be running before our next issue.

The mill upon the National lead, in the upper part of the county, is improving regularly in its yield, and is now paying well. It is operated with great economy. The mill, which is driven by water power, crushes twelve tons every twenty-four hours, all of which is taken from the vein by *two drifters.* The facilities for procuring the rock can no where be excelled.

The California Gold Mining Company at Gold Mountain, seven miles north-east of Alpha, are pushing ahead the construction of their mill with all convenient dispatch. They will use water about half of the year, and have a 25-horse-power engine to use when water fails them. They will be in operation in about six weeks. No stamps will be used. In their stead a set of "Pool's Patent Graduated Rollers" will be used to reduce the quartz to about the fineness with which it usually leaves the stamps, after which it passes through a series of three arastres. There are to be twelve of these arastres put up at the start, in three sets or ranges. It is the intention of the proprietors to add to each of these "ranges" until no gold, worth attempting to save, shall be found in the last one. As the plan is entirely new, we shall

take pains to give a full report of its operation as soon as it shall be under way.

A new steam mill has recently been commenced about one mile from Ophirville. in Placer County.

The *Mountain Democrat*, published at Placerville, says:—" We are in possession of some of the best and most extensive quartz leads in the State, which are worked by good and substantial mills, the most of which have so far proved to be good investments. Prominent among these stands the Pacific Mill, which was the first one erected in this place, and has now been nearly two years in operation. The success its proprietors have heretofore met with has thus far surpassed their most sanguine expectations.

This Company, according to the Democrat, consists of twenty-four stockholders, representing forty-five shares. The mill was started in 1854, and is driven by water power. The yield for the first twelve months not only repaid the entire original outlay for its construction and the numerous improvements, added almost weekly, but also left to the shareholders a very handsome revenue. The fact becoming apparent, that considerable gold was lost by the imperfect manner in which the quartz was crushed, the company went to the expense of $8000 in the erection of arastres, &c., which were finally abandoned for lack of power. Some idea may be formed of the profits of the business, and of this mill in particular, by the following statement from the American:

Profits in March last	$3,375
" April	2,250
" May	3,375
" June	2.700
" July	4,500
Profits for five months	$16,200

Besides leaving a considerable surplus in the Treasury. These are net revenues, after the payment of all expenses. The cost of working the mill and lead is considerable—amounting to no less than seventy-five dollars per day, the daily expense of water alone being thirty dollars.

MINING PAN MANUFACTURE.

This article is one of the most useful in California, and in order to facilitate and improve its manufacture, we find it stated in the Sacramento papers that Messrs. Dickson & Hillhouse have just finished a new and very simple machine for the manufacture of sheet-iron mining pans, without seams and perfectly solid, which is a very great improvement on the old plan. The machine is made on the die and lever principle, and has a stamping power of nearly a ton. With steam-power two gross of these pans can be turned out in a day, while four men can make and perfect one gross with ease in the same time. A patent has been applied for.—*Cal. Journal.*

THE HUNGARIAN AMALGAMATION MILL.

This mill consists of a fixed iron vessel, somewhat of the shape of a soup plate, of a diameter from twenty-four to thirty-six inches, from five to six inches deep, the bottom of which is covered by from fifty to seventy-five pounds of quicksilver, forming an even mirror, through which passes an encased iron spindle which moves the runner or second plate of iron or wood, fitting exactly within the fixed larger one, and continually stirring the quicksilver, or intervening pyrites, or ores, by teeth of sheet iron fixed across its bottom. This upper bowl or runner has a circular hole in the middle, through which the waters coming straight from the stamps, and keeping the finely stamped ores in suspension, are continually rushing into the quicksilver, and are urged on by the following waters and ores under the sides of the mills, where they are carried round many times, being at each round dipped into or brought in immediate contact with the quicksilver repeatedly, by

means of the teeth of the upper runner, before the refuse sand or pyrites can withdraw; which after many turns reach the margin of the mill, where the retiring water lifts them and carries them away.

THE SAN JUAN DEL REY GOLD MINE.

One of the most extensive and profitable Gold Mines in the world is that known as the Moro Velho, located in Brazil, about three hundred miles in a northerly direction from Rio Janeiro. The following is a description of the mine, and manner of working in use four years ago.

"The Mine of Moro Velho was worked for several years by the Padre Freitas, who sold the property, about twenty years since, to the late Capt. Lyon, R. N., and partners; and these gentlemen, in 1834, transferred the mines, estate, &c., to the St. John del Rey Company. On their taking possession, the lode was worked like a quarry, the ore being above the level of the road. The ground worked by the old proprietors, has, however, been considerably opened out in length, and other lodes immediately contiguous to it added.

The depth of the mines is about 66, 40, and 30 fathoms respectively; and the pumping and hauling arrangements are most complete and efficient. There are about 1100 persons now employed; and monthly about 6000 tons of ore are stamped by 96 stamp heads, moved by six water wheels. The ore is crushed by iron stamp heads, weighing about 200 lbs. each, each head giving from sixty to seventy blows per minute. The stone, as it is pulverized, is washed by a stream of running water through very fine copper grates, and then is carried down a slightly inclined plane, covered with hides, which arrest the gold and the heaviest particles of the sand, while the earthy matter passes away.

The skins or hides are taken up every two hours, and washed in separate boxes. The sand of the three head skins (those next the grates) is sent direct to the amalgamation house. The lower skins, being much poorer, are again hung over the strakes,

The process of amalgamation is very simple. The sand is put into barrels with quicksilver, and revolved quickly by a water wheel for twenty or thirty hours, until minute examination proves that all the gold has been taken up by the quicksilver. The contents of the barrels are then gradually poured into the saxe (a long inverted box moving horizontally in a trough) in which the quicksilver (or rather amalgam) is deposited, the sand being washed away at either end. Every ten days the saxe is opened, and the quicksilver or amalgam is passed through chamois leather, which retains the amalgam; and this is burnt off in a furnace yielding from twenty-five to thirty-five per cent. of gold.

We find the position of the Company thus given in the Mining Journal; "This company work three mines contiguous to each other, and drained by the same water wheel; the lode in two of the mines varies in width from 8 feet to 32 feet, averaging 14½ feet; and the third, the Gamba, 4 feet 7 inches. The lodes dip bodily at an angle of 46 deg. at which incline the pumps are carried, and on the same plane the kibbles from the stopes under the inclined shaft are hauled to surface. There are two water wheels for drawing stuff; one for the saw-mill; and one at the reduction-house for working the amalgamation barrels: and six others at the stamping mills, working 96 heads.

The average yield of this mine varies from $7 to $14 per ton of rock. The average yield for 1847 was $10 60.

Later accounts from this mine up to October 1st of last year, still represent it in a flourishing and improving condition. A large number of stamps have been added (about 40), and the present monthly gross receipts of the mine are $51,000. The expenses per month for raising and reducing the ore are $31,000, leaving a monthly profit of $20,000. We have no data from which to determine the amount of ore reduced, or the number of persons employed.

One very important process observed at this mine is a separation of the ores by the hammer. During the month of August last, 252 tons of the gross amount raised, was thus thrown aside. By throwing out the poorer portions of the ore, an equal portion of better rock can be crushed, and the average produce proportionally increased. It is an undoubted fact that must be apparent to every one conversant with mining, that the stamping of poor ores with good, is not merely negatively but positively hurtful; as the gold passing over the riffles and blankets can be more readily separated from a less than a greater quantity of sand. Moreover, it is a useless waste of time and wear and tear of machinery, to crush rock from which no gold can be obtained. An accurate acquaintance with the mineralogical character of the vein-stone which is being worked, will enable any one to select very readily such portions of the ore as may be comparatively worthless.

This process of separation, however, is rarely needed in narrow veins; but in veins averaging from three feet and upwards in thickness, it will almost universally be found a useful and economical process.

Arrastres are extensively used at the Moro Velho mine, for reducing the refuse from the saxe, as described in the above extract from the London Mining Journal. This mine is yet very far from being fully developed, and a great increase over its present yield may be confidently predicted.

The common arrastres formerly used at this mine have recently been changed to the "edge mill," or what is more commonly known in California as the "Chili mill." Had it not been for the difficulty and expense of obtaining castings at this locality, the "edge mill" would have been introduced at the start.

The stamp heads used are of wrought iron, and are forged from ore which is obtained in the immediate vicinity of the mine, and weigh with their stems about 500 lbs. each.

The best idea of the amount of work performed at this mine may be obtained from the fact, that nearly or quite as large an amount of ore was raised and crushed at this single mine during the year of 1855, as was crushed from all the mines throughout the State of California during the same time. The average yield per ton of the mines of California, however, is probably nearly or quite treble that of the Moro Velho mine, and that too, without any rejection or separation by the hammer, as practised in Brazil.

MARIPOSA COUNTY AND ITS MINERAL WEALTH.

The part or portion of land known under the style and name of "The Fremont Grant," says the Mariposa Democrat, and concerning which so much has been said and written, is located within the centre of Mariposa county, and will fully justify all that has been asserted of it, in regard to its great mineral richness. The grant may properly be divided into four great mineral sections, viz: Guadalupe, Agua Frio, Bear Valley, and Mariposa Creek.

The Guadalupe section is too well known to require an extended and minute description—being about five miles in length and four in width, and would require a sufficient amount of water to run one thousand sluice-heads; or, in other words, one thousand sluice-heads of water could be used within this section, which would pay an enormous sum per year to the ditch company who would be so fortunate as to introduce water.

The next section is the Agua Frio district, being about six miles in length, reaching from the Guadalupe district to Bear Valley, and having a width of three miles. Here also could one thousand sluice-heads of water be sold per day.

Next comes Bear Valley district—which is famed for its great power and vast richness. Within this valley alone, some 600 to 800 sluice-heads of water could be sold per day.

With the exception of a small tract of land lying between Bear Valley and Corbitt's Creek, the Mariposa district is the last remaining mineral dis-

means of the teeth of the upper runner, before the refuse sand or withdraw; which after many turns reach the margin of the mi retiring water lifts them and carries them away.

THE SAN JUAN DEL REY GOLD MINE.

One of the most extensive and profitable Gold Mines known as the Moro Velho, located in Brazil, about th northerly direction from Rio Janeiro. The followin mine, and manner of working in use four years ago.

"The Mine of Moro Velho was worked for Freitas, who sold the property, about twenty yea on, R. N., and partners; and these gentlemen, i estate, &c., to the St. John del Rey Compan the lode was worked like a quarry, the ore b The ground worked by the old proprietors opened out in length, and other lodes imme

The depth of the mines is about 66, the pumping and hauling arrangemen There are about 1100 persons now em of ore are stamped by 96 stamp head is crushed by iron stamp heads, wei ing from sixty to seventy blows is washed by a stream of runnin then is carried down a slightly in the gold and the heaviest parti away.

The skins or hides are ta boxes. The sand of the th rect to the amalgamation again hung over the stra

The process of ama with quicksilver, and r hours, until minute by the quicksilver. into the saxe (a lon the quicksilver (or at either end. F amalgam is pas this is burnt o of gold.

We find "This com same wate to 32 fee The lod carried clined stuff am he

...ue dig- ... Five or six ... quartz rock, paying ...is could readily afford to ... of a cubic foot of water,—an ...e a wheel lifting twenty-five or

... of getting water into the county, hitherto, ...ity of a refusal, on the part of Mr. Fremont & ...ater within the limits of their grant; but we are ...s been any application to those parties for this valu- ... mere right of way through the grant cannot, in our opin- ...evented by these gentlemen. Yet it would, most assuredly, ...taining of water, if the people within the county, in connec- ...em, would jointly combine and dig the ditch. At all events, we ... water at any sacrifice, whether of labor, time or expense.

MISCELLANIES.

NEW PROCESS OF MANUFACTURING SODA AND SULPHURIC ACID.

In place of a dull and imperfect review of the "Universal Exposition," it seems better to describe a new process, yet unpublished, which promises to change one of the most important industries of the age.

…tanding the improvements in the manufacture of artificial soda, …cess is still continued in practice with few changes, furnishing …e residues of oxysulphuret of calcium, and preventing the sul-…uric acid from serving several times.

… the great degree of perfection to which the manufacture …w carried; the very perfect condensation of the hydro-…plications; the low price of the materials used, the …d the simplicity of the apparatus required for trans-… into the carbonate; and finally, the fact that the … in connection with that of artificial soda, con-…rical work in which nearly all the products are …ve been proposed have not been adopted, …mmetry of operations, or else because of …hey are adapted only to certain circum-… brought forward escapes these objec-… Professor in the School of Pharmacy … into practice in a manufactory in …ster.

…e of soda by a mixture of oxyd … the reaction in the way de-…follows:

…ce contain some common …hould be proportioned only to …n the crude material. A furnace …reak up the larger lumps. The oxyd … in a fine powder, and should be as pure as

…, instead of the artificial or native peroxyd of iron, …ron) may be employed, or the magnetic oxyd, or even …n the case of the last, the quantity of carbon should be …e metallic iron acts as a reducer of the sulphate of soda. It … seen, that whatever the compound of iron used, there will be …only the peroxyd, and this is regenerated constantly in the opera-…

The mixture of sulphate of soda and oxyd of iron, which is obtained as a residue in the process of decomposing common salt by the sulphate of iron, is readily adapted to Kopp's process, since, if the proportions are correctly taken, it is only necessary to add the requisite quantity of carbon. This carbon may be coke, or any other organic reducing substance; but the quantity will vary with its reducing properties. In England they use ordinary coal.

The amount of oxyd of iron must be such as will combine with all the sulphur of the sulphate of soda to form SFe. For 9 of the pure and dry sulphate, not less than 5 parts of the pure and dry oxyd of iron are required; a small excess of oxyd of iron is advantageous. If the oxyd contains lime it should be removed by treating with hydrochloric acid and washing; for the lime would give rise to CaS, then $CaO\ SO^3$, and then again CaS, increasing unnecessarily the volume of material under manipulation, and causing a loss of carbon and heat. The carbon should not be in excess, as it favors the formation of sulphuret of sodium, and because also of this excess remaining with the sulphuret of iron, will afterwards afford, in the roasting of the latter, some sulphurous acid mixed with the carbonic acid. The proportion of carbon should hence be diminished until there is a minute proportion of the sulphate of soda left undecomposed in the blocks of crude ferruginous soda.

The quantity of the mixture that may be put into the calcining furnace at one time will depend of course on its size: but the amount may be full twice as large as in the Leblanc process, since the ferruginous soda works more easily than the ordinary soda.

For *calcination*, the furnace may be similar to that for the calcareous soda; but to economize heat, there had better be two or three stories, the lowest nearest the fire. The furnace then holds three charges at once, which are moved downward in succession, another being added above when one is taken out below.

The treatment in the furnace is like that for the crude calcareous soda, and the phenomena are nearly the same. The whole softens, becoming pasty, and the fluid as the action goes on disengages a yellow flame; then the action, which has been very bright, diminishes as the flames become less abundant, and when the mass is homogeneous, it is finished. It is then removed immediately from the furnace, being run while still red into a wagon on wheels, in which it cools and solidifies, having been partially covered for security from contact with the air. When cold, it is a block in the form of a parallelopiped, blackish in color and more or less porous, very hard and of considerable density. The surface has a coppery reflection. In fracture, it has a uniform aspect, a crystalline texture, and a greenish and brilliant metallic reflection.

It now remains to treat this crude ferruginous soda, so as to draw off on one side the soluble carbonate of soda, and on the other the insoluble sulphuret of iron. The method used with the crude calcareous soda would give only bad results. In fact, the mass expands on the action of water, becomes very voluminous, difficult to wash, and affords a liquid containing much caustic soda and also sulphuret of sodium.

The washing is however easy, after a preparatory operation which M. Kopp calls "*délitation*." It is as follows.—The crude ferruginous soda left exposed to the air under a shed, undergoes a change, which is the more rapid if the air be charged with moisture and carbonic acid. The lustre fades, the block breaks to pieces, and becomes covered with an abundant blackish pulverulent material; and this goes on so rapidly, that in a few hours it is reduced to a hillock of this powdered substance.

This change is due to the absorption of oxygen, water and carbonic acid, while heat is given out, which without care may rise even to ignition, in which case the powder has a reddish aspect, and contains sulphate of soda with 10 to 15 p. c. of carbonate of iron and a little sulphuret. But this high heat is prevented by removing the powder from the surface as it accumulates, so as to leave the interior open to the air and carbonic acid. Water then separates from it carbonate of soda, and the residue consists principally of sulphuret of iron.

M. Kopp aids the process by an artificial supply of cold and moist carbonic acid, as the action of the air is very slow. This process, which he calls "*carbonation*," is as follows:—In a chamber, at a height of two and a half meters, a grating of cast-iron is placed, whose spaces are one and a half centimetres. The earth is removed to about a depth of one meter. The roof of the chamber is about two and a half meters above the grating. The walls have numerous holes for the passage and circulation of the air. In the lower part, the carbonic acid is introduced. The blocks of crude ferruginous soda are placed on the grating, on their small face; and as they crumble, the powder falls below, where it encounters and rapidly absorbs the carbonic acid. A block of 250 kil. requires as a maximum a space of a meter, and the process is complete in eight or ten days. Consequently a space of 20 meters by 10 will answer for 200 blocks, which will furnish more than 50,000 kilograms in 10 days, equivalent to 5000 kilograms a day. Ten metric quintals of coke, worth in England 7 to 8 francs, suffices to carbonate 90 to 100 quintals of dry and pure carbonate of soda.

The material when ready for lixiviation should be pulverulent, fine, gray

or blackish-gray in color, and without hard fragments. It is well to use a coarse sieve to remove the stony matters present, retaining them to be lixiviated apart, taking care to reject the insoluble residue. The sifted powder forms with water a lye which is clear in five to ten minutes, holding a heavy deposit, with often a coppery reflexion.

The *lixiviation* should be carried on methodically either by filtration or decantation, by means of warm water at 30° to 40° C. Weak solutions are used in lixiviating new portions of the powder.

When the exterior temperature is not too high, the solutions furnish after 24 to 48 hours, without concentration, an abundance of finely crystallized limpid carbonate of soda. By dropping in a bit of dry carbonate of soda the crystallization is often hastened.

The residue, principally sulphuret of iron, is received on a filter or porous surface. In this state, it alters slowly. It is dried by heat or pressure and made into a brick. It is so combustible that it will take fire below 100° C., when the drying is nearly complete. This sulphuret affords the sulphur for making sulphuric acid, in which change the iron becomes peroxyd, and is then ready to be used again. It is thus seen that a single proportion of sulphur may be utilized a large number of times, in transforming common salt into sulphate of soda. But the oxyd of iron gradually becomes impregnated with the impurities of the common salt, the sulphate of soda and coal, and it must then be renewed; yet it may be used when it contains even 40 p. c. of impurities.

When the oxyd of iron contains sulphate of soda, it is necessary to change the proportions of the mixture for the crude soda. It has been found by experiment that the proportions most convenient are—

Sulphate of soda, ...	125 kilograms,
Peroxyd of iron, proceeding from this sulphuret, . . .	140 "
Carbon, ...	70 to 75 "

and these proportions should be preserved for the subsequent operations as long as the rotation of the same oxyd and same sulphuret of iron continues.

The same process may be used with the oxyds of manganese and zinc, but with greater difficulties, as the "délitation" and "carbonation" in these cases are more complicated.

GROOVING AND POLISHING OF HARD ROCK AND MINERALS BY DRY SAND.

The phenomena about to be described were observed in the Pass of San Bernardino (California), in 1838.* This Pass is one of the principal breaks through the southern prolongation of the Sierra Nevada, and connects the Pacific slope with the broad and low interior plain of the Colorado Desert. It is bounded on each side by high mountains; the peak of San Bernardino rising on the north to the height of about 8,500 feet, and San Gorgonio on the south, to about 7,000. The elevation of the summit level is 2,808 feet above the Pacific, and the width of the gap at that point is about two miles; from this the ground slopes each way very gradually, the grade or descent on the east, for about 28 miles, being on an average, 69 feet per mile.

On this eastern declivity of the Pass—the side turned toward the Desert—the granite and associate rocks which form the sharp peak of San Gorgonio, extend down to the valley of the Pass in a succession of sharp ridges, which being devoid of soil and of vegetation, stand out in bold and rugged outlines against the clear unclouded sky of that desert region.

It was on these projecting spurs of San Gorgonio that the phenomena of grooving were seen. The whole surface of the granite, over broad spaces,

* A brief notice of these phenomena is given in the writer's Preliminary Geological Report, accompanying the Report of Lieut. R. S. Williamson, of a Reconnoissance in California, House Doc., 129, p. 27. Washington, 1855.

was cut into long and perfectly parallel grooves and little furrows, and every portion of it was beautifully smoothed, and though very uneven, had a fine polish. For a moment it was impossible to realize the cause of all this abrasion performed in a manner so peculiar; the action of glaciers and drift was thought of in succession; but the appearance of the surface was so entirely different from that of rocks which have been acted on by these agents, that I could not regard them as the cause. While contemplating these curious effects, the solution of the problem was presented. The wind was blowing very hard, and carried with it numerous little grains of sand. When I stooped down and glanced over the surface of the rocks, I saw that they were enveloped in an atmosphere of moving sand, which was passing over and accumulating in deep banks and drifts on the lee side of the point. Grains of sand were thus pouring over the rocks in countless myriads, under the influence of the powerful current of air which seems to sweep constantly through this Pass from the ocean to the interior.

Wherever I turned my eyes—on the horizontal tables of rock, or on the vertical faces turned to the wind—the effects of the sand were visible: there was not a point untouched, the grains had engraved their track on every stone. Even quartz was cut away and polished; garnets and tourmaline were also cut, and left with polished surfaces. Masses of limestone looked as if they had been partly dissolved, and resembled specimens of rock-salt that have been allowed to deliquesce in moist air. These minerals were unequally abraded, and in the order of their hardness; the wear upon the feldspar of the granite being the most rapid, and the garnets being affected least. Whenever a garnet or a lump of quartz was imbedded in compact feldspar, and favorably presented to the action of the sand, the feldspar was cut away *around* the hard mineral, which was thus left standing in relief above the general surface. A portion, however, of the feldspar, on the lee side of the garnets, being protected from the action of the sand by the superior hardness of the gem, also stood out in relief, forming an elevated string, osar-like, under their lee.

When the surface acted on was vertical and charged with garnets, a very peculiar result was produced; the garnets were left standing in relief, mounted on the end of a long pedicle of feldspar, which had been protected from action while the surrounding parts were cut away. These little needles of feldspar tipped with garnets, stood out from the body of the rock in horizontal lines—pointing like jewelled fingers in the direction of the prevailing wind.

They form in reality a perfect index of the wind's direction, recording it with as much accuracy as the oak trees do, in the region about San Francisco, where they are all bent from the perpendicular in one direction, or in some places lie trailed along the ground. All these little fingers of stone pointed westward, in the direction of the valley of the Pass, to which the wind conforms. We experienced this wind before reaching the point of rocks and the sand drifts; it blew with great force, and seemed to be a great air current, as uniform in its direction and action as the great currents of the sea. It flows into the interior with singular persistence and velocity, sweeping down over the slope of the Pass, not in fitful gusts and eddying whirls, but with a constant uniformity of motion unlike any of the winds of our Atlantic seaboard, or of the plains.

The Pass would, in fact, appear to be a great draught-channel, or chimney, to the interior, through which the air rushes inland from the cool sea, to supply the vacuum caused by the ascent of a column of heated air from the parched surface of the great Desert. This Pass is the only break of any magnitude in the mountain chain for a long distance, and as an air-channel, holds the same relation to the Colorado Desert as is sustained by the Golden Gate, at San Francisco, to the broad interior valleys of the Sacramento and San Joaquin.

The effects of driving sand are not confined to the Pass; they may be seen

on all parts of the Desert where there are any hard rocks or minerals to be acted upon. On the upper plain, north of the Sand Hills, where steady and high winds prevail, and the surface is paved with pebbles ot various colors, the latter are all polished to such a degree that they glisten in the sun's rays, and seem to be formed by art. The polish is not like that produced by the lapidary, but looks more like lacquered ware, or as if the pebbles had been oiled and varnished.

On the lower parts of the Desert, or wherever there is a specimen of silicified wood, the sand has registered its action. It seems to have been ceaselessly at work, and when no obstacle was encountered on which wear and abrasion could be effected, the grains have acted on each other, and by constantly coming in contact, have worn away all their little asperities and become almost perfect spheres. This form is evident hwen the sand is examined by a microscope.

We may regard these results as most interesting examples of the denuding power of loose materials transported by currents in a fluid. If we can have a distinct abrasion and linear grooving of the hardest rocks and minerals, by the mere action of little grains of sand, falling in constant succession and bounding along on their surface, what may we not expect from the action of pebbles and boulders of great size and weight, transported by a constant current in the more dense fluid-water? We may conclude that long rectilinear furrows of indefinite depth may be made by loose materials, and that it is not essential to their formation that the rocks and gravel, acting as chisels or gravers, should be pressed down by violence, or imbedded in ice, or moved forward *en masse* under pressure by the action of glaciers or stranded icebergs. Wherever, therefore, we find on the surfaces of mountains, not covered by glaciers, grooved and polished surfaces, with the furrows extending in long parallel lines, seeming to indicate the action of a former glacier, we should remember the effects which may be produced during a long period of time by light and loose materials transported in a current of air; and which consequently may be produced with greater distinctness, and in a different style, by rocks moved forward in a current of water. The effects produced by glaciers, by drift, or moving sand, are doubtless different and peculiar—so different and characteristic, th t the cause may be at once assigned by the experienced observer, who can distinguish between them without difficulty. It is, however, possible that after a sand-worn surface, such as has been described, has been for ages covered with moist earth, a decomposition of the surface would take place sufficient to remove the polish from the furrows and leave us in doubt as to their origin.

If it were possible, it would be exceedingly interesting to ascertain the length of time it has required for the little grains of sand to carve the surface of the granite ridge to its present form. How inappreciably small must be the effect produced by a single grain! And yet by their combined and long continued action mighty effects are produced. That the action of the grains, singly, is not visible, is proved to us by the polished snrface, for no one grain cuts deeply enough to leave a scratch. Ages have doubtless elapsed since this action of the sand began, and we cannot tell how deep the abrasion has extended; cubic yards of granite may have been cut into dust and driven before the wind over the expanse of the Desert.—*Wm. P Blake.*

DIAMONDS.

During a lecture on Mineralogy, at the Truro Institution, Capt. Mahmoud, as an instance of the practical importance of being able to ascertain the scale of hardness of minerals, related a circumstance that occurred to a gold-digger. The man, when working at the diggings, found a rock crystal, and thinking it was a large diamond, he immediately left his work and went home. He invited a friend to take tea with him, and produced the supposed diamond on the tea-table. His friend offered 200*l.* for it, which the digger refused to

take. He made his voyage to England, and on arriving in London went to a mineral dealer, and offered him the precious stone for sale. The dealer, however, on trying its hardness, found that it was only common quartz, and after convincing the digger of his mistake, he gave him a few shillings for it on account of its beauty.

QUICKSILVER.

According to Dumas, the following mines yielded annually as follows:—Almaden, in Spain, from 2,700,000 to 3,456,000 lbs. avoirdupois; Idria, 648,000 to 1,080,000 lbs.; Hungary and Transylvania, 75,600 to 97,200 lbs.; Deux Ponts, 43,200 to 54,000 lbs.; Palatinate, 19,440 to 21,600 lbs.; Huancavelica, 324,000 lbs.

No less than 836,850 pounds of quicksilver were exported from California during the last six months ending July 1st.

PLATINA.

This metal in Russia is generally found in the sediment of auriferous sands, or their vicinity. Its principal locality is in the sands of the Ural to the north, especially in the districts of Tahil and Goroblahodat. Since the discovery of platina in 1824 to 1851, there has been found 82,440 lbs.; of this 79,600 lbs. came from Nijne Tahil, 1280 lbs. from Goroblahodat, and the rest from the washings of the several sands in the Ural. It has not so much been sought after lately, the coinage of it being abolished in 1845.

A LAKE OF PITCH.

Silliman's Journal contains an account of that remarkable curiosity "the pitch lake of Trinidad," W. I. It is situated on the western shore of the Island, near the village of La Braye, which is built on a foundation of hard pitch. The lake stands about 60 feet on a plateau above this village, is circular, and half a mile in diameter, surrounded on all sides with a dense forest. Its face is intersected with a network of water channels, which give it the appearance of marbled paper. The surface of the pitch is pretty hard, and when the water channels are dry, it can be passed over on foot. In the centre of the lake the pitch appears to be constantly and silently rising up *en masse*, and what is very singular, numerous pieces of wood are constantly coming up to the surface from below. These are from one to several feet in length, and are forced by the peculiar pressure to assume an upright position, so as to appear all over the lake like stumps of trees protruding through. It is believed that this pitch lake is boiling slowly below. Streams of sulphuretted hydrogen gas frequently issue from beneath, the temperature of which is 97° Fah. The centre of the lake is somewhat plastic, but around the sides the pitch is very hard. The water in the streams and small pools is pure and soft; fish are numerous in them, and alligators make them their habitation. Large springs of petroleum are in its vicinity, and about a mile northward there is a bed of brown coal cropping out upon the sea shore; it is about 20 feet thick, and appears from its dip as if it passed under the lake. The pitch is of great depth, for it has been dug into 18 feet in many places. It is believed to be a submerged bed of vegetable matter, undergoing slow distillation by volcanic action underneath. This store of bitumen appears to be inexhaustible. It is used with wood for fuel by the American steamers plying on the Orinoco river. Mixed with pebbles and sand it makes excellent pavements, and ground floors of houses. With ten per cent. of rosin oil, it makes a good pitch for ships. The Earl of Dundonald has purchased a tract of 26 acres of it, and has instituted experiments to discover, if possible, some means for making it a substitute for india rubber and gutta percha water-proof or vulcanized fabrics; and he has already made some vulcanized cloth, which, from appearances, bids fair of future success. If such a result crown his efforts—and every person must wish him success—such an inexhaustible supply of cheap materials as this lake furnishes, will soon bring down the price of such goods in our country, and thus confer unspeakable benefits upon our people.

MINING MAGAZINE.

EDITED BY

WILLIAM J. TENNEY.

CONTENTS OF NO. VI., VOL. VII.

ARTICLES.

COMMERCIAL ASPECT OF THE MINING INTEREST.

Contents.

COALS AND COLLIERIES.

IRON AND ZINC.

JOURNAL OF GOLD MINING OPERATIONS.

JOURNAL OF COPPER MINING OPERATIONS.

MISCELLANIES.

THE

MINING MAGAZINE:

DEVOTED TO

Mines, Mining Operations, Metallurgy, &c., &c.

VOL. VII.—DECEMBER, 1856.—No. VI.

ART. II.—THE IRON MANUFACTURE OF GREAT BRITAIN—THEORETICALLY AND PRACTICALLY CONSIDERED. By WM. TRURAN, C. E. No. 9.

SECTION XII.—ON THE ECONOMY OF HEATED AIR AND ITS CONNECTION WITH CERTAIN FORMS OF FURNACE.

THE remarkable effects produced by a heated blast in reducing the yield of fuel, and augmenting the make of blast furnaces in certain localities, requires from us some explanation.

The late Mr. Mushet in his papers on iron and steel; Dr. Thompson in his report to the British Association; and Dr. Clark in his paper to the Edinburgh Society, attribute the superiority of a heated, as contrasted with those of a cold blast, to the cooling effect of the latter. Hence the very common impression, that the heat maintained at the zone of fusion in the hot blast furnace is more intense and concentrated than that in the cold blast.

This explanation, though generally adopted as correct, is manifestly very wide of the real cause. To maintain active combustion of the fuel, atmospheric air is required; every pound of carbon burnt with air to carbonic acid, evolves a definite amount of heat. The time occupied in the evolution of this heat will depend entirely on the rapidity with which the oxygen of the air can be brought in contact with the carbon. The temperature attained will be in an inverse ratio to the time occupied in the evolution of the heat. If, then, the requisite mechanical means are adopted for bringing the oxygen in contact with the carbon, the highest temperature which it is possible, under any circumstances, to produce, may be maintained in the hearth of a cold blast furnace. With a dry cold blast, the high temperature attained is exhibited in the rapid reduction of the most refractory ores. How are we to reconcile this attainment of a maximum temperature with the assumed cooling effects of a cold blast? If it has a cooling tendency, the greater the volume delivered in a given time, the more rapid will be the reduction of temperature, but in practice it is the reverse; an augmentation of the volume is followed by a corresponding increase of temperature.

Equally unsatisfactory is the explanation, that the hot blast is better fitted for supporting combustion. Before we can allow this assumed superiority, we must know in what respect the composition of the hot differs from the cold blast. If a hot air supports combustion better than a cold, the relative proportions of oxygen and nitrogen composing atmospheric air alter with the accession of caloric; or the cold air contains some deleterious ingredient which is got rid of by heating. But the relative proportions of these gases are not altered, and whatever substance may be in mixture exists to the same extent in the blast after heating.

The expanded volume of the heated air is supposed to be more favorable to perfect combustion, in consequence of the enlarged surface presented by the oxygen for combining with the carbon. This involves the supposition that the atoms of oxygen are expanded by caloric, whereas the expansion of gases is due to the greater separation of the individual atoms from each other.

The explanation which we offer of the superior effects of a heated blast, as contrasted with those of a cold, is based on the practical working of blast furnaces on both systems. From numerous observations, and the results of several experiments, we are disposed to ascribe the superiority to two separate causes: first, to the caloric thrown into the furnace along with the blast, enabling a corresponding quantity of coal to be withdrawn from the burden of materials, with a proportionate reduction in the volume of blast, the effects of which are seen in an augmentation of the make, but do not result in any saving of fuel; secondly, to the reduced volume of blast and the large proportion of caloric which it carries into the furnace, causing a diminished consumption of carbon in the upper parts of the furnace, the effects of which are seen in the quantity of fuel being reduced below that due to the caloric conveyed into the furnace by the blast.

In reference to the first-named cause, which is not attended with any saving of coal, the conveyance into the furnace of a given quantity of caloric in combination with the blast, cannot result otherwise than in a reduced consumption of furnace coal; but this reduction is met by a stove consumption of precisely equal amount; therefore, the advantages of the heated blast are limited to the increased produce from a given size furnace.

Our explanation of the augmentation of make is founded on the well known fact, that any reduction in the burden of coal is followed by an increased make of iron, whether the blast employed be hot or cold; but there is this difference in their systems: with a cold blast the reduction is uniformly followed by an alteration in the quality from gray to white; and similar results occur with the hot blast, when the burden of ore is composed chiefly of hematite or silicious ores. But with ores having a notable percentage of carbon in combination, chemically or mechanically, a reduction from the usual quantity of fuel is not so readily seen in the quality of the resulting crude iron.

In illustration of the difference in make, attending alterations in the burden of coal, we may mention that the ordinary yield of coal to produce carbonated iron at the Dowlais furnaces with a cold blast, is 50 cwts., and the make with this proportion 80 tons weekly. On reducing the quantity of coal so that the yield averages 40 cwts., the make increases to 106 tons, but the quality is very little above white.

Whenever we observe the make to be very large, we find the yield of coal low. At the Cwm Celyn furnaces, where the make occasionally reaches so high as 240 tons a week, from a furnace smelting argillaceous ore, hematite, and cinders, the yield of coal is as low as 28 cwts.; but then the quality is excessively bad, and incapable of being manufactured into other than the coarsest varieties of bar iron.

From this connection of the make with the consumption of coal, detailed at greater length in the section on yields, it appears that within certain limits, the total consumption of coal is constant with the same blast, and that the make is nearly in an inverse ratio to the burden of coal.

If, then, by heating the blast, and thus conveying into the furnace a quantity of caloric available for reducing the ore, we are enabled to withdraw a portion of the coal burden, the make will be doubly augmented—first, by as much as the reducing power of the additional caloric at bottom; secondly, by the reduced proportion of carbon in the burden of materials to the same volume of blast. Estimating the make of iron and yield of coal with the cold blast at 100 tons, and 40 cwts. respectively, and the saving of furnace coal and consumption of stoves at 5 cwts., the increase of make with a hot blast may easily be ascertained. In the first place, assuming that the heat evolved by the combustion of the 5 cwts. of stove coal possesses the same reducing power as an equal weight charged at top, the increase from this source will amount to 12½ per cent: in the second place, from the reduced burden of coal charged at top, there is an increase of 14 per cent.; total, 26½ per cent.* This fairly represents the increase of make on the substitution of a hot for a cold blast; but of the increase it will be observed that 14 per cent. is owing to the reduced burden of coal; on a cold blast furnace this reduction would be followed by the same increase of make. Hence the hot is superior to the

* As this rate of reduction, with the diminished burden of coal, is incompatible with the production of highly carbonated crude iron, for the time required for deoxidation of the ore and carbonization of the iron is not altered by the temperature of the blast, the volume of cold air entering the stoves is diminished, so that the make is very little higher than that with a cold blast. In Wales, indeed, with the lean argillaceous ores the production of carbonated crude iron of a given quality, from a furnace on hot blast, is in no wise superior to that with the cold. In the case, however, of irons requiring an inferior degree of carbonization the make is greatly in favor of the hot blast system.

cold, only in as much as the reducing power of the caloric thrown in with the blast.

But this slight superiority disappears altogether if the quality of the resulting metal is taken into consideration. We find that in melting the hematites, silicious ores, and varieties of the argillaceous ore, any reduction in the quantity of coal is seen in a corresponding deficiency of carbon in the metal. This inferiority of hot blast smelted iron is easily explained. By throwing in caloric with the blast at bottom, a quantity of the coal previously required may be withdrawn from the burden, without impairing the rate of smelting; but as the hot blast conveys no carbon into the interior, the volume of gaseous carbon available for the deoxidation of the ore and the carbonization of the crude iron, is reduced in the same ratio as the burden of coal.

If the temperature of the blast be elevated to the melting point of the ore, the fuel may be withdrawn, with the exception of a quantity containing a sufficiency of carbon for the deoxidation of the ore. But with the withdrawal of the fuel, we are deprived of the carbonating medium, and the iron so obtained would be nearly void of carbon. Hence, for every degree that we elevate the temperature of the blast, a quantity of coal may be withdrawn from the burden; but the carbonization of the metal is thereby lessened and the quality deteriorated.*

With the carbonaceous ores and varieties of the argillaceous, a diminution of the burden of coal on the application of a heated blast is not followed by the deterioration of quality observed in other cases. This is, doubtless, owing to the large quantity of carbon, chemically and mechanically combined with these ores. If the entire burden of coal was withdrawn, they could be reduced into metallic iron of a high quality, by the employment of a blast, heated to their melting point. This from numerous observations we are inclined to fix at between 1300 and 1400°; and, owing to the peculiar manner in which the carbon is combined with the metal, the time required with other ores for communicating the carbonaceous principle is unnecessary; consequently the make of the furnaces may be largely augmented without injury to the quality of the iron. By withdrawing nearly the entire quantity of coal now used in smelting, and communicating the requisite caloric through the medium of the blast, the make may be augmented beyond any thing attainable with the present system of smelting. It must be borne in mind that two-thirds of the present consumption of limestone is necessary for fluxing the earths

* This deficiency of carbon in hot blast smelted irons is strikingly shwon in all analyses of crude irons, as well as their inferior specific gravity. The generally low tensile strength of these irons also, is due to the inferior degree of carbonization, and comparatively large percentage of earthy matters in combination; for, as a general rule, the weight of alloy is nearly uniform, and any deficiency of carbon is met by a corresponding increase of silica and other earth.

combined with the coal. Under this mode of smelting these ores, the materials charged into the furnace for the production of a ton of crude iron will weigh 36 cwts.—34 cwts. of ore, and 2 cwts. of limestone. Now 240 tons of iron in a week has been obtained from a medium size furnace, but this was accompanied with a consumption of more than 1,000 tons of solid materials, and the production of 700 tons of liquid matter. With an equally large consumption of materials, composed of fusible carbonaceous ore, and a minimum dose of limestone, the make of iron would be nearly 600 tons weekly. Looking, however, to the richness of this ore, its comparative freedom from earthy matter, and low melting temperature, we venture to predict that the time is not distant, when a weekly make of 800 to 1,000 tons will be as common as 150 to 200 tons under the present system.

The proposal to smelt these ores, without the employment of fuel in the furnace may at first sight appear chimerical, but when the whole of the circumstances attending the present system of manufacture are taken into consideration, the intelligent smelter will see reason for questioning the policy of using the present large quantity of coal. In the concluding paragraphs of this section we shall enter into the beneficial effects which the altered mode of smelting would have on the quality of the resulting crude iron.

Hitherto we have considered only the effects of a heated blast in augmenting the weekly make of metal, under circumstances where its application is not attended with a saving of fuel—the consumption in the heating stoves being equivalent to that saved from the burden entering the furnace. We will now proceed to examine the superior effects of a heated blast over a cold, as exhibited in a saving of fuel—the reduction in the furnace consumption being considerably greater than the coal burnt in the stoves.

The most remarkable instances of saving of fuel on the substitution of the hot for a cold blast have occurred in Scotland. At the Clyde works, where the new system was first applied, the consumption of coke per ton of crude iron was reduced from 60 to 38 cwts. by the consumption of 5 cwts. of coal in the heating stoves. Here was a clear saving of 17 cwts., allowing that the calorific value of the coke was only equal to that of the raw coal, though in practice it is considerably higher.

In this instance, the superiority of a heated blast is shown in a very striking manner; 5 cwts. of coal burnt on the heating stove grates are of equal calorific value with 22 cwts. of coke consumed in the blast furnace.

No explanation, that we are aware of, has ever appeared of this circumstance—the very different reducing powers of coal consumed in the furnace as compared with that consumed in the stove. The fact, that for 5 cwts. consumed in the stoves 22 cwts.

may be withdrawn from the burden on the furnace, has been repeatedly adduced as evidence of the saving which follows on the use of heated air, and of the immense value of that invention. But is the saving altogether due to the caloric carried into the furnace by the blast? The 22 cwts. coke burnt to carbonic acid in the blast furnace evolve a certain quantity of caloric; 5 cwts. of coal burnt to carbonic acid on the stove grates evolve a proportionately smaller quantity of caloric, but since not more than three-fourths of the quantity evolved is absorbed by the blast, the remainder escaping into the atmosphere, it follows that the caloric evolved by the combustion of 3.75 cwts of coal in the stove grate, conveyed by the blast into the furnace, is equal to that evolved by the combustion of the 22 cwts. of coke. Apparently, then, the caloric conveyed into the hearth with the blast is six times more effective in the reduction of the ore, than that evolved by the combustion of the coke in the same region.

From what cause does this superiority of the caloric conveyed by the blast over that created by combustion within the furnace arise? Can it be that one pound of carbon burnt outside the furnace evolves as much heat as six burnt inside? Or, is it that, of the heat evolved by the combustion of the 6 lbs. inside, five-sixths is evolved at such an elevation, or in such a manner that it renders no service to the operations?

We can very well imagine that, by heating the blast, the caloric thus commuuicated to the materials permits of an equal weight of coal being withdrawn from the burden, but under such circumstances there is no saving of coal. When, however, we observe that the quantity withdrawn amounts to six times that communicated by the blast, the matter is well worth a patient investigation.

The insufficiency of the common explanation that the heated blast is better fitted to support combustion, is very apparent. If we admit the correctness of this explanation, we must concede this superiority in all cases of combustion whatsoever; in the secondary processes of the manufacture; also in the furnaces of steam engine boilers, and grates of every kind. Writers on the advantages of a heated blast, in freely crediting the new system with a large saving of fuel, amounting in some cases to more than one-half of the consumption, have neglected to show any reason for the saving being confined to the fuel used in the blast furnace: in reality, none exists; and if heating the blast be the primary and unconnected cause of the saving, an extension of the principle should result in an equally great economy of fuel in every other process, and in every instance of combustion of coal. But this is more than the most partial claim for it; they acknowledge that in practice, the beneficial effects of a heated blast are confined to the blast furnace.

The reason of the superiority being confined to blast furnaces

remains to be ascertained. Did we observe any fixed ratio between the saving of furnace coal and consumption in the stoves, an important step would be gained; but while the stove consumption is nearly uniform in the various districts, the reduction in furnace coal by applying the hot air system, is subject to great variation, apparently depending on a number of concurrent circumstances. Hence, we are led to the conclusion, that the superior economy with a heated blast in certain districts, is due to causes other than the quantity of caloric imputed to the blast.

The subject is one which has engaged our attention for some years, and during our residence at the Dowlais and Hirwain works, we failed not to collect all the information bearing on the point which these establishments afforded. At the Dowlais works the frequency of the alterations in the burden on the furnaces, mode of blowing, and volume of blast, furnished valuable data for guidance in the enquiry. When it is known that our observations at these works alone, on the 18 blast furnaces, extended over a period of 13 years, the sufficiency of the data so obtained for such an important inquiry can hardly be questioned. We do not, however, rely entirely on the information collected at these works, but shall from time to time draw on notes taken during our frequent visits to all the other iron-making districts of this country and the Continent, as corroborative evidence of the correctness of our views and deductions.

In seeking for a satisfactory solution of the great saving of fuel obtained under certain circumstances, by using a heated blast, the primary question to be solved is—what proportion of the carbon charged into the furnace is burnt to carbonic acid in the hearth, or otherwise rendered available in the reduction of the ore?

For the complete combustion of each pound of the carbon of the coal, the quantity of atmospheric air chemically required is nearly 153 cubic feet.* This is the quantity necessary, supposing that all the oxygen of the air enters into combination with the carbon; but as in practice this precision cannot be obtained, we may safely assume 160 cubic feet as a minimum supply.

Knowing, then, the consumption of carbon and supply of air in a given time to a blast furnace, we can ascertain by calculation how far the consumption in practice assimilates to that chemically required for perfect and profitable combustion of the coal.

* Of the carbon consumed in the furnace 3.6 cwts. is absorbed by the deoxidation of the ore (peroxide) and on an average 5 cwts. in the carbonization of the metal. These quantities, however, are absorbed under whatever conditions the furnace may be working as regards fuel, ore, flux, blast, &c.; therefore it is not necessary to take them into consideration in an inquiry concerning the economy of heated air.

At the Clyde works, prior to the use of heated air, the weekly consumption of coke, yielding 87 per cent. of carbon, was 375 tons. The furnaces were under blast 156 hours weekly, and the supply of blast averaged, after allowance for leakage, 7,140 cubic feet of air per minute. Hence, the supply was at the rate of 85 cubic feet to each pound of carbon.

After the application of the hot blast invention, the fuel was coal, yielding 76.5 of carbon; the weekly consumption averaged 554 tons with the previous volume of blast; for each pound of carbon 67 cubic feet of air was delivered into the furnace.

The four new furnaces at the Dowlais works burn weekly 1,088 tons (long weight) of coal, containing over 87 per cent. of carbon; the delivery of air during the period they are under blast, 156 hours, averages 21,560 cubic feet, or 90 feet of air to the lb. of carbon.

The 14 other furnaces at the same works have consumed 3,911 tons of coal in a week, with a delivery of blast of 77,000 cubic feet per minute; for each lb. of carbon there was 81 cubic feet of air.

The foundry iron furnace at the new furnaces belonging to the Dowlais company, blown with heated air, has exceeded 180 tons of iron in a week, with a consumption of 50 cwts. of coal per ton, and a volume of blast averaging 5,390 cubic feet per minute. This is equal to 78 cubic feet to the lb. of carbon.

The foundry iron furnace at the Hirwain works, blown with heated air, averages 90 tons of pig iron weekly, with a consumption of 34 cwts. of coke, yielding 94 per cent of carbon to the ton, and a volume of blast averaging 2,541 cubic feet per minute. Dividing the blast by the consumption of carbon per minute, we find that for each lb. there is 68 cubic feet.

The 6 blast furnaces at the Langloan works, Scotland, average 150 tons each, or 900 tons of iron weekly; the average yield of coal is 38 cwts., yielding 76.5 of carbon. The blowing engine delivers 14,824 cubic feet of blast per minute: estimated on the consumption of carbon per minute 336 lbs., each lb. of carbon is supplied with 44 cubic feet of air.

At the Gartsherrie works, Scotland, 8 of the furnaces are blown with a single engine, which delivers 24,335 cubic feet of air per minute. The 8 furnaces make on an average, 1,120 tons weekly, with a yield of coal of 40 cwts. to the ton; hence, the consumption is 22,40 tons, containing 76.5 per cent. of carbon. At 156 hours blowing weekly, the supply of atmospheric air is at the rate of 55 cubic feet to each lb. of carbon.

We shall annex one other statement of the proportion usual in practice. Messrs. Playfair and Bunsen, in their report on the gases of the Alfreton furnace, state the consumption of coal, containing, by their analysis, nearly 75. of carbon, at 31,200 lbs. per day of 12 hours. The blast to this furnace is stated to have been delivered by a pipe 2.75 inches diameter, at a pressure of 3,375 lbs. per square inch, and temperature of 626°. Now, we find from experiments on a large scale, that after allowing for the expansion of the air, a pipe of this bore delivers 1,020 cubic feet of atmospheric air per minute. Divided by the consumption of carbon in the same period, we have 63 feet of air to each lb. of carbon.

From what we have here advanced the fact is patent, that the atmospheric air thrown into the present blast furnaces is manifestly inadequate to the complete combustion of the carbon of the fuel. For admitting that all the air discharged by the tuyere pipes is effectually decomposed, and yields up its oxygen to the carbon for the formation of carbonic acid, the quantity is in every instance insufficient. The examples given are not selected for their apparent great deficiency, but as representing the maxima and minima of supply. In the case of the Scotch furnaces the

maximum quantity of air is scarcely one-third of that chemically required. But from the quantities stated there must be deducted the leakage at the tuyeres, when the proportion of atmospheric air to carbon is still further reduced. If the deficiency was small, or did we in any instance observe an excess, we might conclude that the proportions were such as could be obtained in practice, but with the knowledge that it varies from one-half to three-fourths of the quantity absolutely required, it is desirable to examine how combustion of the fuel can be effected with such limited quantities of atmospheric air.

The oxygen in the largest volume of air to carbon is barely sufficient to form carbonic oxide, but the production of this gas in the zone of fusion involves the assumption of a temperature greatly below the melting point of the ore. Besides which the quantity received by the Scotch furnaces is not more than the half of that necessary for the production of this gas, and is altogether insufficient to enter into combination with the carbon in any known proportions.

If the volume of blast employed for the respective furnaces was under that required for the combustion of the carbon in the hearth, with the evolution of a maximum quantity of caloric, the employment of a larger volume would result in an increase of temperature, and the production of a superior iron; but whenever the volume is augmented above that given, without a corresponding augmentation of the burden of coal the temperature is reduced, and the separation of the metal being less perfect, the iron produced is of an inferior quality.

Under these circumstances, then, we must conclude that the weight of carbon charged at the throat of the furnace is diminished during the descent, and that the proportion which the quantity ultimately available for combustion bears to that charged, is fairly represented by the difference in the quantity of atmospheric air delivered with that absolutely required for combustion.

Calculated on the quantity capable of being burnt to carbonic acid, we find that at the Dowlais works under the most favorable conditions now extant, only 56 per cent. of the coal entering the furnace evolves useful heat; and at the Langloan works it is only 27.5 per cent. of the quantity entering. The remainder, with the exception of a minimum quantity absorbed in the deoxidation of the ore, and carbonization of the metal, may be considered as altogether unproductive in the smelting operation.

The assumption, however, that from one-half to three-fourths of the present large consumption of fuel is so much waste, must be supported by other facts: these we shall adduce, when the correctness of our views will be apparent, and the connection of the waste with the saving of fuel on the employment of a heated blast demonstrated.

From this point the inquiry is inseparably connected with the

form of the interior of the furnace, and embraces the combined effects of a heated blast and certain form of furnace on the economy of fuel. For the due consideration of the subject, we will recapitulate various deductions drawn from the proportions detailed in previous sections.

1. For the production of carbonated crude iron from the leaner varieties of argillaceous ores, the hematites, and silicious ores, the solid materials according to the present system of working must be in the furnace 40 hours.

2. If the descent is accelerated beyond this rate, the quality of the resulting iron is deteriorated.

3. If the stated proportion of carbon to ore and flux is diminished, the quality is deteriorated in the same ratio—a reduction from 50 to 42 cwts. of coal resulting in the production of white iron, accompanied however by an increase in the make in nearly an inverse ratio to the yield of coal.

4. If the volume of blast is augmented over that given, the rate of descent is accelerated, followed by the production of a less carbonated iron; and if largely augmented by the production of white iron—in either case the make is increased.

5. A reduction of the width of the furnace at the throat, is followed by a deterioration in the quality of the crude iron: but the quantity in this case is not augmented.

Hence, with ores, fuel and flux of the same quality we have a deterioration in the quality of the metal from three very different causes—an increased volume of blast; a reduction in the proportion of fuel; and a contraction of the throat of the furnace, are respectively followed by the same injurious effects. But if separately examined, each of these causes tends to a diminution of carbon in the zone of fusion—hence, the white iron.

By augmenting the volume of blast, the temperature is temporarily increased, combustion of the fuel and reduction of the metal proceed more rapidly, and the descent of the ore and coke is accelerated beyond the rate at which the ore and reduced metal can receive the carbonating principle. But the mere acceleration of descent is not the sole cause of the rapid deterioration observed in the quality. The increased volume of blast thrown in augments the ascending column of gases, and in the same ratio as the volume of air is increased is the velocity of the ascending column augmented. Hence, in the throat the point of exit, the increased draught is followed by a greater combustion of the easily inflammable coal. It is impossible to say with accuracy what proportion of the coal is thus consumed in the throat, but when it is considered that a slight draught is sufficient for its immediate ignition, and that the heat thus generated, communicated to the ascending gases, by expanding their volume, augments the draught and combustion, the probability is, that a moiety of the calorific power of the fuel is thus unprofitably expended.

A contraction of the throat, by increasing the intensity of the draught in an inverse ratio to the area, is followed by an increased consumption of coal—the increase being nearly in the same ratio

as the augmented velocity of the ascending column. This was the case at the narrow-throated experimental furnace at the Dowlais works. And in examining the yields of the various furnaces in that establishment, we find that those with the narrowest throats consume the largest quantity of coal for a given weight of iron smelted. Compared with each other also, we find that the yield of coal is principally determined by the volume of blast delivered, and the area provided for its escape at the throat.

The combustion of a portion of the fuel in the throat necessarily involves the assumption that a high temperature is there maintained in coal-fed furnaces. From observations we are of opinion, that where the throat is one-half the diameter of the furnace, the temperature with a blast proportioned to the production of gray iron ranges between 900 and 1,000°. In furnaces having a smaller throat, the temperature is considerably higher. Doubts may be entertained as to the existence of this high temperature, but on this point we would direct attention to the brickwork of the throat as conclusive evidence that a very high temperature prevails. From an examination of 12 of the Dowlais furnaces, blown out for repairs after having been under blast for periods varying from 8 to 13 years, we ascertained the fact that the brickwork at the throat is destroyed more rapidly than the vertical work at the level of the boshes. The diameter of the throat in the majority was nearly one-half of that of the furnace; in these the destruction of the brickwork at the throat, was more than twice as great as in the lining above the original level of the boshes. In the furnaces with narrower throats the depth of brickwork removed was nearly three times that at the lowest side of the lining. From the throat the loss rapidly diminished in the descent, until on arriving at the former level of the boshes it was reduced to a minimum.

The wear or destruction was not so great in the hot as in the cold blast furnaces, which is easily explained. As a rule, the materials in the throat of a hot blast furnace are colder than those in the cold blast furnace. To understand this anomaly it must be borne in mind, that the heat maintained in the throat of the furnace is not produced by conduction from below, but is the result of a partial combustion of the fuel in that region; and since the rate of combustion is regulated by the area of escape and volume of ascending column, the hot blast furnace having a diminished volume of air, the velocity of escape is diminished in the same ratio as the original volume of air is less than that thrown into the cold blast furnace. But the temperature is reduced in a still greater ratio. In consequence of the caloric thrown in at the bottom, a smaller proportion of fuel is required for the maintenance of the smelting process. Forming, then, a lesser portion of the whole volume of solid materials charged, the temperature maintained by the ignited fuel in the throat is not

so high, and conjointly with the diminished quantity of blast required, the superior economy of the heated air is seen in the reduced consumption of coal. But the economy of fuel with the heated blast, is entirely due to the comparative coolness maintained in the throat, causing a smaller consumption of the coal in that locality. If, then, we can lower the temperature in the throat of the cold blast furnace, an equal economy of fuel will be ensured, and the superiority of the heated blast in this respect ceases. In support of this opinion, we may adduce some remarkable effects observed in the working of hot blast furnaces.

We have frequently noticed, that when a furnace which has been blown with a heated blast, and the accompanying reduced burden of coal is suddenly changed to a cold blast by withdrawing the fires from the stoves, the descent of the materials is accelerated. For 24 to 30 hours after the substitution of the cold blast, the furnace makes more iron with the original burden of coal, and no deterioration is to be seen in the quality of the produce. But after that period the rate of descent is checked, and the quality changes; in from 36 to 40 hours the furnace has returned to its original rate of working, and the quality is deteriorated to white. At the end of 48 to 60 hours, the furnace has settled down to the usual rate of working with a cold blast, and the quality has finally receded to that produced under other circumstances with the diminished consumption of coal. If the burden of coal is increased sufficiently to keep the furnace permanently on a similar quality of iron with the cold blast, the make will be in an inverse ratio to the burden.

When the make with a hot blast has averaged 105 tons a week, the immediate substitution of a cold blast has temporarily increased the production, at a rate equal to a weekly make of 115 to 116 tons; on the increased burden of coal, added as a compensation for the withdrawal of the hot blast, taking effect, the make recedes to 96 tons weekly.

With those who have not studied the subject, and noticed the different effects produced on the furnace, the hot blast has the merit of effecting a large saving in the consumption of coal, and augmenting the weekly produce in a remarkable degree; and under circumstances which should never occur, the hot blast, doubtless, effects important changes. It is a question, however, whether such changes cannot be effected by more direct means.

If the heating of the air is the real cause of the larger make and greater economy of material, how is it that the make is augmented, and the economy greatest on substituting a cold blast under the circumstances detailed? According to the published opinions of the ablest advocates of the hot blast system, the admission of large volumes of cold air would be attended with an immediate reduction of the temperature in the hearth. The temporary increase of make is direct evidence that the temperature

is higher. It is a common, though erroneous opinion, that a hot blast creates a higher temperature than a cold under similar conditions, but in this case we see the superior temperature attained by a cold blast.*

When the whole of the circumstances are taken into consideration, we apprehend that the real cause will appear evident. While the furnace is working with the heated blast, the burden of coal has been reduced, and the quantity of blast also having been reduced, the draught and consequent consumption of coal in the throat and upper part of the body, is diminished. Of the coal charged, a larger portion remains for combustion in the hearth than occurs with the larger consumption and cold blast. On the substitution of the cold blast an ample supply of carbon is present for the maintenance of an intense heat; combustion proceeds more rapidly; and the quantity of metal deposited in a given time is augmented. But the improvement is local. With the admission of the cold air and the increased volume of the ascending gases, the draught created by the increased velocity of escape causes a partial combustion of the coal in the throat. Hence, the proportion of carbon which subsequently descends to the hearth is diminished. The injurious effects resulting from the loss of carbon by the fuel are not immediately seen. For the first 24 or 30 hours the altered blast is acting on the fuel which had passed the throat, with the inferior draught of the hot blast in operation. Directly, however, that the coal in the upper part of the furnace at the time of alteration reaches the zone of fusion, both cinders and iron present altered appearances. The former changes from gray to dark, spongy or black, and the latter from dark gray to mottled and white.

The conclusion that we have adopted, as being most consistent with the observed facts of the case, is, that the temporary acceleration is due to the greater volume of carbon presented to the blast; and was the furnace so constructed that the coal could reach the level of the hearth with nearly its original volume of carbon, and there be converted into carbonic acid, the superiority commonly accorded to the hot blast would no longer exist.

It is seen that for a period of 24 to 30 hours a cold blast acts more advantageously than a hot, the make of iron is even greater, while the yield of coal is not augmented, but actually reduced by as much as the consumption in the stoves with the hot blast. Now, as the burden of coal in the Dowlais hot blast furnaces is

* The greater make for a limited time, on the substitution of a cold blast on a furnace previously working with a hot, is known to several furnace managers, but we have endeavored in vain to obtain from them a rational explanation of the cause. If known to the numerous authors who have written on the hot blast, the difficulty of reconciling it with the glowing accounts in favor of the new system, probably operated to its suppression, for we do not discover the slightest allusion, to this important fact in any of their papers.

but three-fourths of that on the cold, the continuance of the furnace on the hot blast burden for a period of 30 hours, demonstates that at other periods there occurs with the cold blast a loss or waste, of full one-fourth of the entire consumption over that occurring with the heated blast. And as the volume of blast delivered into the hot blast furnace is manifestly incapable of yielding more than nine-sixteenths of the oxygen necessary for the combustion of the coal charged into the throat, we learn, that of the coal consumed by the Dowlais furnaces considerably less than the one-half contributes to the reduction of the ore and flux.

This partial combustion of the fuel in a region where the caloric evolved is of no service, but decidedly injurious to the ore, is common to all furnaces of the present construction, but is most apparent in coal-fed furnaces, especially in those of Scotland. After what has been stated of the Dowlais furnaces using a more difficult combustible coal, the immense disproportion of coal to blast, and indeed to the work performed, which we observe throughout that country, must be apparent to the student. If more than the one-half of the coal used in the Dowlais furnaces is wasted, and no other term can appropriately be applied to the coal consumed in the descent, what proportion of the more inflammable Scotch coal can be expected to reach the zone of fusion, in furnaces of a construction even more unfavorable to economy of fuel than those at Dowlais?

Furnaces fed with coke are worked with nearly equally great waste of fuel. This fuel is not so readily ignited as coal, but the porosity of its structure, by offering an extended surface of carbon, facilitates a partial combustion, and during its descent the loss is little inferior to that with coal.

The waste of carbon in the blast furnace is not confined to this country. On the continents of Europe and America the consumption is equally large. With nearly similar appliances, and the construction of furnaces adopted in this country, a superior economy of fuel is not attainable at home or abroad. Notwithstanding statements to the contrary, we find that the American and continental furnaces consume as much, if not more, coal and coke than similar furnaces at home; and although the withdrawal of the gases for economical purposes is largely practised, American hot blast anthracite furnaces consume from 40 to 50 cwts. of an anthracite containing 94 per cent. of carbon, for the production of one ton of crude iron from comparatively rich ores.

But in some of the continental charcoal furnaces we do not observe that the consumption of carbon is thus in excess of the blast. In such furnaces, however, there are not the same causes in action for the partial consumption in the descent. The width of the throat is large, and the volume of blast, owing to the defective machinery employed, very inferior. For the same ca-

pacity the volume is not more than the half of that employed in the coal and coke furnaces of this country. Where the conditions are thus favorable, the ton of iron is made with 18 cwts. of charcoal, but to work to this yield the furnaces are driven very slowly; consequently the draught through the throat is insufficient for the ignition of the coal, and nearly the entire quantity of carbon charged, descends to the hearth for combustion with the oxygen of the blast.

The remarkable effects produced by a heated blast on coal-fed furnaces, are not visible in the case of charcoal furnaces previously working to the low yield we have named. A saving of charcoal certainly attends the application of the system, but it is not commensurate with the consumption of carbon in the stoves. Where the carbon is correctly proportioned to the volume of blast and the work to be performed, a given weight converted into carbonic acid in the furnace, reduces a greater quantity of ore than the caloric evolved by a similar weight burnt on the stove grates.

To what cause are we to ascribe the inability of the hot blast to compromise fuel in the case of charcoal furnaces carrying a high burden?

The structure of the fuel operated on, has been considered a sufficient explanation of the widely different results obtained with the heated blast; but apart from the known fact, that with the same fuel the cold blast is for a limited time superior, we do not well see how the temperature of the blast can be beneficial to one and injurious to another coal. It must be borne in mind, that whatever fuel is used, its temperature is elevated during the descent, and the blast acts on carbon already at a red heat. If a stream of heated blast be directed on masses of different qualities of cold coal, coke, and charcoal, the sudden accession of temperature has very different effects; on some of the raw coal it causes a partial coking, on others a disintegration of the particles; on coke it has little effect, owing to its porosity offering a comparatively large surface for the absorption of caloric; on the charcoal from its more open texture still less. But whatever fuel is used in the blast furnace, at or before its arrival in the hearth it is converted by the evolution of its gaseous constituents into a porous coke; the softer coals from having been coked under great pressure are of a denser structure than they would have been if coked prior to their introduction. The difference in the densities of the respective cokes is met by employing a blast of great or lesser pressure. At the zone of fusion, then, the difference in the structural arrangement of the respective fuels is not such as to explain the superiority of the hot blast in particular localities.

Charcoal has the least density of any fuel employed in iron smelting. If the inferiority of the hot blast with this fuel is due to its structure, it is but reasonable to infer, that with the lightest

cokes the saving is at a minimum; but that the density of the charred fuel does not determine the amount of saving with a heated blast is very evident, if we take the Scotch coals as a standard. These when charred are probably the lightest of any used in iron-making; yet it is in Scotland that the application of the system produces the greatest saving.

The superior smelting power of charcoal, under the circumstances detailed has been explained by a foreign writer, on the supposition that the smaller dimensions of the coal conduce to a more perfect combustion. Instances were quoted, showing that in smelting with anthracite the consumption of carbon is treble that with charcoal. As a remedy for this inferiority of anthracite it was proposed to assimilate its dimensions to that of charred wood by breaking the coal into small pieces of only a few cubic inches in each. But it is well known that coal thus broken small cannot carry so high a burden in the present furnaces as when in large masses. Besides, this economy of charcoal is not observable in furnaces having narrow throats, and propelled by a volume of blast large in proportion to the area for its escape. In the United States there are numerous furnaces consuming from 35 to 40 cwts. of charcoal to the ton of iron, or fully twice the consumption at other furnaces, where the rate of driving is much slower. With similar ores, but differently constructed furnaces and variable volumes of blast, the consumption of carbon ranges from 18 to 40 cwts. This variation in the consumption with different rates of driving, is evidence that a large portion of the carbon is consumed in the descent, without yielding any beneficial effect in the charcoal furnace, equally with the coal and coke-fed furnaces of this country.*

The superior economy of fuel under certain conditions with a heated blast; the superiority of a cold blast under different conditions; the heavy burden of ore carried by some charcoal furnaces; and the universal deficiency of atmospheric air for the combustion of the carbon of the fuel entering the throat—clearly point to a large consumption in the upper parts of the furnace. While the maintenance of a high temperature in the throat, as exhibited by the rapid destruction of the brickwork, can only be accounted for on the supposition that the coal is there ignited and partially consumed. Altogether we imagine that the con-

* The late Mr. Mushet considered the comparatively small consumption of carbon in charcoal furnaces as principally due to the great richness of the ore smelted causing a limited flow of cinder. To a certain extent this is correct: with the same ores the richness in metal, by regulating the production of cinder, will at all times influence the yield of fuel, but the rule is not of universal application. The carbonaceous ores of Scotland are, when calcined, the richest in metal of any ores wrought for iron-making, while the flow of cinder is probably the smallest with which the operations of a blast furnace have ever been conducted. Notwithstanding these favorable circumstances the consumption is from twice to three times that in charcoal furnaces.

clusions which we have formed are based on such facts that their accuracy cannot be disproved.

The rapid partial combustion of the coal in the throat, explains the greater carbonating power of a given weight of coal in large blocks as compared with the same in smaller pieces. At the Dowlais works, it is impossible to make foundry iron with the existing furnaces, when the pieces of coal are below a certain size. They contain the same volume of carbon, and on arriving at the zone of fusion ought to yield nearly the same quantity of caloric and gaseous carbon; but in practice it is otherwise. We are well aware, that a blast acting on a number of disjointed pieces does not create so high a temperature as when directed on a single piece; but the greatly inferior power of the smaller pieces in the Dowlais furnaces must otherwise be accounted for.

Of the combustion of a considerable portion of the fuel in the vicinity of the throat there cannot be a doubt. The depth of the portion consumed of each piece will be the same whether they are large or small; but owing to the extended surface presented by the smaller pieces in proportion to their cubic contents, the quantity consumed is augmented nearly in the same ratio as the surface. Hence, by reducing the dimensions of the fuel, the consumption in the throat may be so large as to destroy its most valuable properties.

The remedy for this waste is obvious. Let the throat of the furnace be enlarged. With every enlargement the area will be increased, and the velocity of the ascending column of gases diminished in an inverse ratio. The enlargement may advantageously be extended until it equals the diameter at the boshes, from which point upwards the interior would be cylindrical, and at the top, being from 8 to 9 times the area of the present throats, the velocity of escape will be largely reduced. The rapid draught now maintained in the throat will then be reduced to a minimum, and the partial consumption of the coal no longer occur.

The temperature of the upper strata of materials will be reduced in the same ratio as the draught is diminished in velocity. Hence the coal, no longer subjected to the high temperature of the throat, by absorbing caloric more gradually, will not undergo that sudden transformation into coke which involves the partial combustion of the carbon. The full calorific power of the carbon being retained for useful combustion in the hearth, the quantity of coal now used in smelting may in every instance be largely reduced. At works where apparently the economy of fuel has been carried to a great length, the quantity actually necessary for the reduction and carbonization of the ore is under the one-half of that consumed, while in works which have not practised equal economy, the consumption is from three to five times the quantity required for the ore, and in the case of the carbonaceous ores the

entire quantity of coal now used may be withdrawn, with every advantage to the make of the furnace and quality of the iron.

In furnaces constructed so that the carbon of the fuel shall descend for combustion at the tuyeres, the superior economy of the heated blast in certain localities will no longer exist. The cost of the heating apparatus, and expense of maintenance will be saved; and the present furnaces with the enlarged throat and a cold blast will smelt a greater weight of ore, with a given volume of carbon, than is now accomplished with the hot blast. There will be greater economy with the cold blast, inasmuch as the entire quantity of caloric evolved during combustion will be available for the reduction of the ore, instead of a portion only, as is the case with the coal consumed in the heating stoves.

With a reduced consumption of coal combined with the altered form of furnace, the quality of the iron cannot be otherwise than greatly improved. All the coals used in smelting contain sulphur in great or lesser quantities, and not unfrequently potash and other substances equally injurious to the quality. The quantities brought in contact with the ore, will vary with the consumption of coal. If the quantity of coal per ton of iron is reduced one-half, these impurities will be diminished in the same ratio in the resulting metal. But if, as in the case of the carbonaceous ores of Scotland, the entire consumption of coal is withdrawn, from 24 to 36 cwts. of sulphur also will be withdrawn weekly.

The ashes of the coal are liquefied by combining with a portion of the lime used as flux. If the coal contain a considerable quantity of ash, the limestone required for its fusion may be equal to that required for the earths combined with the ore. At the Scotch furnaces, when coking was considered necessary to the success of the smelting operation, the consumption of coal averaged nearly 8 tons to the ton of pig iron. This coal contained above 6 per cent. of ashes, principally silica, amounting altogether to nearly 10 cwts. to each ton of iron; for its fusion an equal weight of limestone was required in addition to that required for the ore. On the substitution of the more fusible carbonaceous ore, along with an enlargement of the filling throat, the consumption is reduced to 38 cwts. of raw coal, the quantity of ash is reduced in the same ratio, and the ton of iron is smelted with 5 cwts. of limestone.

In the reports of the British Association the reduced consumption of limestone in the Scotch furnaces is ascribed to the use of heated air. It is difficult to see such connection between the temperature of the air and the quantity of lime necessary for fusing a given quantity of silicious earth, as is there inferred. Certain it is, that in Wales the hot blast effects no saving of flux; and it would be more correct to ascribe the reduction effected in the Scotch furnaces to the diminished quantity of sili-

cious earths, requiring a proportionately less weight of limestone for the formation of a fusible cinder.

It may justly be remarked, in reference to the foregoing—if this waste of carbon is going on, how is it that the numerous chemists who have analyzed blast furnace gases have not drawn attention to the subject? Messrs. Bunsen, Playfair, Ebelman, Scheerer and others, have demonstrated the presence of carbonic oxide—the medium through which the carbon escapes—in varying quantities. The proportion which it forms by weight in the column at the period of escape ranges from a fraction to 42 per cent. Now, on consideration, it is apparent that if carbonic oxide be a necessary, or an unavoidable ingredient, the variation in quantity would not be so great. This discrepancy has received some attention from analytical chemists, but has not satisfactorily been accounted for.* The size of the furnace, composition, and nature of the ore, fuel and flux have been assigned as causes, but if practically examined, their insufficiency is very evident. That the dimensions of the furnace and composition of the materials influence the process of reduction cannot be doubted, but there is no connection between the influences thus exerted and the presence of carbonic oxide in large quantities in the throat as being essentially necessary to the success of the smelting operation.

It must be borne in mind that in the inquiries which have been made respecting the composition of blast furnace gases, the object invariably has been to ascertain their value for heating purposes. On examining the various memoirs on the subject, it is seen that the labors of the analytical chemist have been exclusively directed to the composition of the gases, without reference to the arrangements under which they have been produced. Having ascertained the presence of carbonic oxide—a combustible gas—in quantities sufficient to give it a commercial value, the circumstance is forthwith treated as a valuable discovery; a patent is secured, and attention directed to the caloric which

* Messrs. Bunsen and Playfair account for much of the difference observed in the analysis of charcoal furnace gases, when compared with those of English coal-fed furnaces, in the reduced dimensions of the materials in the former offering a larger surface—at least a *hundred times* the surface presented by the materials in the latter. Now, the greater porosity of the ores smelted in the furnaces of this country amply compensates for the larger dimensions of the materials; on this score, then, the charcoal furnace does not possess any advantage. But on what data do Messrs. B. and P. base their extraordinary assumption respecting the larger surface? To augment it one hundred times, the pieces must be reduced in size to the one-hundredth of their present dimensions; allowing three inches as a fair mean of the whole, to attain this increase of surface the materials must be reduced to a fine powder. It is questionable, if with similar ores and fuels, the materials in the continental furnaces are broken so as to offer more than twice, or thrice the surface.

the gas gives out when burnt with air to carbonic acid. Meanwhile the point to which attention ought to be directed is entirely overlooked. The presence of carbonic oxide in large quantities in the gases from one furnace, and its absence in those of other furnaces, obviously show a defect in the arrangements provided for the perfect combustion of the carbon. If the carbon can be burnt to carbonic acid in one furnace, thereby rendering all its caloric, surely it is much better to seek to obtain similar results in other furnaces, than to burn to carbonic oxide first, and after its escape from the furnace, by a further supply of air, to carbonic acid. Yet this is now done in the furnaces from which the gases are withdrawn for subsequent combustion. To burn to carbonic acid at first, it is only necessary to attend to the quantity of carbon, the volume and disposition of the blast, and to protect the carbon from combustion in the throat and vicinity. Altogether we are of opinion, that the labor expended by chemists in analyzing furnace gases for the determination of their combustible value has been misdirected, and their collection and combustion a clumsy expedient for recovering a portion of the caloric of the carbon charged in excess of the quantity absolutely required.

That chemists in their researches have not given sufficient attention to the causes which conduce to the presence of carbonic oxide—the gas of highest value for heating—we may remark that neither Messrs. Bunsen and Playfair, nor the continental chemists give the quantity of atmospheric air delivered into the furnace under experiment. This omission is fatal to the correctness of the conclusions drawn by chemists of blast furnace operations generally. A knowledge of the alterations in composition which the ascending column of gases undergoes during its ascent, and the composition and quantities of the ore, fuel, and flux used, to be of value, must be accompanied by the volume of air consumed. This usually weighs three times as much as all the other materials. Now, in the various inquiries no reference is made to the quantity, its sufficiency or otherwise, for combustion. Had this been done, its insufficiency to convert the carbon charged into carbonic oxide would have been apparent. The inquiries appear to have been conducted on the assumption, that the volume of blast was correctly proportioned to the requirements of the carbon.

The analyses, however, so far as they go, are remarkably confirmatory of the position we have taken. If the composition of the gases from the Baerum charcoal furnace be contrasted with those issuing from the Alfreton coal-fed furnace, and the sectional forms of the furnaces be noted, it is very evident that the form of the latter is not favorable to economy of fuel, which is borne out by the analyses. For while the Alfreton gases are observed to be richer in carbon as they approach the throat, not-

withstanding the influx of carbonic acid expelled from the limestone, and the gaseous products of distillation from the coal, the Baerum gases are seen to decrease in carbon, and at the surface a given weight of the escaping gas contains one-fourth less carbon than it did at half the depth of the furnace. This is only what should be, when it is considered that the moisture, carbonic acid, and volatile matters evolved from the materials augment the volume of gas in the higher regions, and thereby diminish the percentage of carbon. In the Alfreton furnace, however, while similar causes are at work, tending to diminish the percentage, the combustion in the progress upwards through the confined throat is such, that the increased volume of gas contains a larger percentage of carbon than existed in the lesser volume at half the depth.

Calculated by weight we find that a given quantity of gas from the Alfreton furnace contains nearly twice the quantity of gaseous carbon which escapes from the Baerum furnace; under such circumstances, then, the superior economy of fuel in the charcoal furnace is readily explained.

(To be continued.)

Art. II.—GOLD ORES AND THEIR WORKING.

Continued from page 358, Vol. 7.

The experiments of extracting the gold by means of roasting have been fairly and fully tried under the auspices of the Russian Government, and the conclusion drawn from the facts, that it was disadvantageous to follow that plan. The same experiment was tried by M. Boussingault at Marmato, but with the addition of common salt in the roasting process, and found to be productive only *with that addition.*

I think it may safely be averred, that the use of fire in dissipating the excess of sulphur, in the pyritous ore, will inevitably result in a considerable loss of the gold contained in the ore.

"Gold melts at 32° Wedgewood's thermometer, and what is very remarkable is, that it is more difficult of fusion in the shape of filings and grains than in larger masses. Gold which has been subjected to a degree of heat barely sufficient for its fusion, seems to undergo a kind of ebullition. This circumstance was noticed by Hornberg and Macquer in the action of the burning glass as well as when a small globule of the metal was acted on by the blowpipe. Macquer asserts that it rose in vapor, to the height of *five or six inches*, and attached itself to the surface of a silver plate which it entirely gilded." *Rees' Encyclopedia—article Gold.*

The only safe method to pursue under the present state of knowledge in the working of gold ores, will be to reduce them to

the finest possible state of disintegration, and then amalgamate and wash them carefully, regularly and slowly. The concentrated tailings should in all cases be preserved. Where large quantities of ore are worked, the accumulation of tailings becomes a matter of serious inconvenience; the mining operations must be continued to preserve the good condition of the mine, else it would be well sometimes to cease that work, and re-operate upon the sands on hand.

The gold veins afford many phenomena of great interest, unconnected with their intrinsic value, the study of which may, perhaps, throw additional light, not only on their formation, but also upon the means to be used for extracting the gold from the ore. A constant record of such phenomena as meet the attention should be kept and each opportunity seized to subsequently pursue the investigation of them. Many moments that else would pass unprofitably by, will thus be made valuable, and if they should not lead to any final important results, will at least have a beneficial effect in schooling the mind to close watchfulness and observation. The active superintendence of a large and working mine, will not allow of many moments of leisure for recondite investigations, and the *honest* fatigue of the body will not sanction the *stealing* from the hours of slumber, much time for noting down the observations of the day; still if the effort is made, much can be accomplished in the occasional intervals between labor and repose.

I have now concluded the description of the veins and the ores of the gold field. Daily, much is seen that cannot be explained. There are many phenomena to which I have not alluded, because in some instances I have not studied them sufficiently to be able to clearly describe them, and in others I wish to be sure of the seeming facts, lest an imperfect view may be calculated to mislead. The temptation to form hypotheses is nowhere more strong, than in the description of mineral veins, so many attractive facts are continually pressed upon the attention, for which the mind earnestly endeavors to discover the cause. The questions will continually arise, Are the principles of the formation of mineral veins understood? Are the forces still in existence by which these veins were produced? My own convictions lead me to embrace the negative side of the first question, while, in regard to the second, I think there is but little doubt that the mineral veins are now forming, the same as they ever have been; the vital principle of their construction is not inert; it still acts, slowly it may be, by human computation of time, but with rapidity and velocity when compared with the cycles through which the earth has passed, and geological changes are still progressing. Nor is it a mere combination of accidental circumstances or phenomena, which regulate or constitute the stratification of the various rocks which form the surface of the earth. We find that

harmony, order and law, pervade all nature; each body in the stellar system moves obedient to gravitating principles; light has its governing laws; the atmosphere, in its construction and motion, produces evidences of design and a directing Intelligence; and can it be supposed, that while law and order overshadow and invest all else of created matter, that the positions of the great strata of the globe are the result of mere chance, devoid of system, or pervading rule? It cannot be; chaos and confusion cannot exist under the fiat of a Supreme Intelligence. Surely that page, upon which the record of earth's changes has been indelibly traced, since the moment that the creative fiat went forth, must possess indubitable proofs of the utmost perfection, in the harmony and arrangements of the characters inscribed upon it; and were our knowledge adequate to the task, we could peruse there, the history of every mutation the world has ever undergone. As the light of advancing research and science is reflected upon the phenomena around us, we shall see clearly, where now our vision is dim and uncertain, and then it will be apparent to all who will investigate, that the now seeming irregularities and incongruities shall be the effect of an all-pervading law, which acts with undeviating certainty and exactitude.

I cannot close this section of my subject more appositely, than by quoting from the views of that good and learned man, President Hitchcock, upon the systems of mountain chains: "But there is too much evidence of uniformity, and even identity, in the manner in which different chains have been elevated; too much proof of occasional paroxysmal vertical movements, and of intervening long periods of repose, not to admit that law has presided over the phenomena."—*Hitchcock's Geology.*

On the Roasting of the Pyritous Ores.

The question of the practicability of roasting the pyritous ores, to produce a greater disengagement of the auriferous particles, is one of vital importance to the interests of those engaged in gold mining. The pyritous ores being, as has been shown, those in which the gold is most frequently disseminated, a variation in the percentage of their productiveness is worthy of the closest attention. It is a subject which has undergone much scrutiny, and which among the operators in gold ores is still a mooted point. To my own view it appears a simple matter, which has many facts to place it beyond doubt. My own experience has shown me, that when the ores are roasted in open heaps in reverbatory furnaces, or otherwise, they will not yield as much gold as a similar portion of the same ore, taken from the same heap, and equally rich, will do without being roasted. The gold in the sulphuret of iron is always in the state of mechanical mixture, but of exceedingly extreme divisibility; so minute are the particles, even in rich specimens, that they are not visible to the naked eye;

cannot while in the matrix be seen with the most powerful glass, but still, upon the reduction of the ore to an impalpable powder, and separation by washing, are plainly visible in the aggregate. From the extreme minuteness of the particles, I am inclined to think that the upward current of air, caused by the fire during the roasting of the ore, will bear them away, even as a light breath of wind will carry off the leaf gold in a gilder's room. The far smaller size of the particles in the ore than those instanced as an illustration, renders the idea still more plausible. It is not lost in the ashes of the heap, or in the soil at the base of it; for all are scraped up together, and pass through the mill and the amalgamators, and still the result falls short of that obtained from the unburnt ore. Can any chemical change occur in the gold? Can it at so low a temperature be vaporized, or oxidized? Can it be that the gold is burned by the flames of the fire? Some metals, we know, when in very minute particles, will burn in the flame of a common fire. Bright filings of iron will burn with a brilliant scintillation when carefully thrown into a flame; copper filings also will readily ignite under similar circumstances, and if the fact is proved that the combustion of the finely divided gold occurs in an ordinary fire, the loss attendant upon the roasting process is easily accounted for.

"I am of opinion that the above only proves what has long been known, that gold in minute quantities can be burnt in a high temperature with the addition of a stream of oxygen gas; consequently roasting of pyrites will not do. Now it seems to me that the only method to obtain the gold out of pyritous ore, is to destroy the affinity between the sulphur and iron by slow decomposition."—*MS. Correspondence.*

Trehern, at Marmato, roasted the ore in a reverbatory furnace, and though the show of gold was great, it only yielded about one-fifth of what was obtained from an equal portion of the unroasted pyrites.

Leay, at Marmato, roasted his ore and found he got less gold than he would have obtained by the most ordinary method of the Batea. He roasted his ore to that degree, "that the color of the slime, which escaped in abundance from the stamp-pits, was deep-red-brown, or hematite-red."

Again, he found one-third of the gold remained after roasting, in some manner associated with the sulphuret of silver, and other products formed by the process of roasting.

Degenhardt has an opinion that the gold forms a sulphuret and is perhaps carried off through the chimney, on account of the silver, which formerly was alloyed by the gold having entirely disappeared during the process of roasting.

"Gold is not directly attacked by sulphur at any temperature; but when fused with the alkaline sulphurets, is rapidly acted on with the formation of a double sulphuret, in which the sulphuret of gold acts the part of an acid."—*Phillips' Metallurgy.*

"I am fully impressed with the belief that the ore if over roasted will cause you a loss of that gold, which could have been much easier obtained by simply stamping it, and causing it to pass over mercury or skins."—*MS. Correspondence.*

From the experiments instituted in Russia, it would appear that a great loss results from roasting the auriferous ores. Through the kindness of a friend a MS. translation of the record of experiments has been placed in my hands, together with much correspondence from others upon the same subject, with full permission to make such use of the matter contained therein, as I may deem advisable; I have availed myself of some of the suggestions embraced in them. I do not think the Russian experiments have been published in this country; should such be the case however, their practical value will amply justify their republication at this time. I give the article entire.

On the loss of Gold and Silver in Roasting.

An article read in the assembly of German Naturalists, at Jena, in September, 1836.

In the auriferous localities of the mines of Ecatherineburg, gold is extracted partly from veins in Berezofsk, and partly from alluvial sands. The quartz rock which forms the auriferous veins, is treated by means of stamping in water in a perfectly new machine. The powder arising from the stamps passes directly upon horizontal tables, where it is conveniently washed, and the schlich obtained by this operation, and which they call "black," is submitted to a new washing, to take out the gold, upon washing tables for cleansing similar to those employed in Hungary before the introduction of amalgamating mills. The general richness of the veins of Berezofsk is of 2 zolotnicks $\frac{72}{96}$ per 100 poods; the black schlichs from 5 to 7 zol. for the same quantity. The waste schlichs as assayed by washing are worth $\frac{10}{96}$ of a zol. per 100 poods. It is two years since M. Varinski, lieutenant-colonel of the corps of mines, employed at Ecatherineburg, thought of using, during the amalgamation of the schlichs obtained by washing, a mixture of sulphuric acid, to derive the advantage of the action of electricity in amalgamation. This process submitted to a comparative proof of so long a duration, with the apparatus for amalgamation of Hungary and many others, was found to be superior for the treatment of auriferous schlichs. Many assays were made for showing that the waste schlichs of ores and sands, which did not give in washing more than 10 a $\frac{15}{96}$ of gold in 100 poods, submitted to the amalgamation by the process of M. Varinski, gave 2 a 3 zolotnicks per 100 poods. Many of these schlichs elevated themselves from a holding of $\frac{1}{3}$ of a zolotnick to 12 zol.; the repeated assays made lately on this subject show, that during the treatment of schlichs obtained by stamping and washing of ores, and by the washing of auriferous sands, they obtained by amal-

gamation a double quantity of gold, compared with the ordinary stamping and washing of those schlichs which have not a holding superior to 3 zol. per 100 poods.* In case of its being richer then the amalgamation loses in proportion its superiority. After being convinced of the advantage evidently offered by amalgamation in the treatment of auriferous ores and sands, it was natural to ascertain if this process was applicable to the extraction of gold and silver from matts arising from the fusion of auriferous ores of silver in the works of the arrondissement of Altai; amalgamation direct of the ores of this country, seeing the poverty of their holding, it being only 2 zol. of silver per pood, was disadvantageous, because under the general rules of amalgamation it followed, that for this success there should be at least 6 zol. per pood. For this purpose some poods of this matt, containing by assay $13\frac{1}{8}$ zol. of silver per pood were carried from the works of Altai to Ecatherineburg; the quantity of gold was not determined, therefore M. Varrenski thought it requisite, as having to treat the matt by amalgamation, to convince himself of its contents of gold and silver by the dry way, that is to say, by scorification and cupellation. The results of this assay were curious and important, for they showed that during the preliminary roasting of the matts, the assays showed less silver and above all less gold, than when the matts were submitted directly to scorification and cupellation without a preliminary roasting, thus:

1. The matt not roasted was found to have of silver 13 $\frac{66}{96}$ zolotnicks, and $\frac{70}{96}$ of gold; or, altogether, of auriferous silver 14 $\frac{40}{96}$ zol.
2. The same matt roasted in a crucible covered with another and hermetically luted gave 13 zol. of silver, and $\frac{64}{96}$ of gold, in all 13 $\frac{64}{96}$.
3. Lastly the same matt roasted upon a tile in a muffle, gave after scorification and cupellation, a holding of silver of 10 $\frac{80}{96}$ zol. and $\frac{32}{96}$ of gold, in all 11 $\frac{16}{96}$ of auriferous silver.

From which they concluded that the preliminary roasting in crucibles hermetically sealed, lost 4 $\frac{3}{4}$ per cent of silver, and 20 per cent. of gold. That roasting on uncovered tiles made a loss of 21 per cent. of silver, and 40 per cent. of gold.

Lastly, to avoid the loss resulting from the roasting of the ore, 5 poods of matt were submitted to amalgamation in the tubs with the addition of sulphuric acid, without a preliminary roasting. The first attempt succeeded badly, for after working three days they did not obtain all of the amalgam, and the loss of mercury was very considerable, probably because one part of it was transformed into sulphuret of mercury; because, during the mixtures of the matts with the water and sulphuric acid, there was found a great quantity of sulphuretted hydrogen gas. On the contrary, the amalgamation of roasted matts made an amalgam, but the loss of gold and silver during the roasting was very considerable. This loss of metals during the roasting of the matt

* £2 10s. sterling per ton.

gave rise to the supposition that at the moment of evaporation of the sulphur and of the other volatile substances, the portions of the precious metals are carried off, mechanically mixed with thin vapors, the same as lead volatilizes itself when a current of gas passes over its surface. Gold is raised with the greatest case when it is disseminated in such minute particles, and it would be retained in this form in the air, with the same ease as when it is suspended in the liquids.

The chief of the mining staff, who was then inspecting the works of Siberia, was cognizant of the experiments of Varinski, offering evident proof that the loss of precious metals resulted from the roasting of substances which contained them, and the idea occurred to him that there would be a similar loss during the roasting of the matts of the furnace at the works of Altai. On his arrival at the works of Bamarul, he made experiments upon the roasting of the matts in the furnaces and in the open air. The results of these experiments are shown in the following table, proving that the more complete the roasting is, the greater is the loss of metal, particularly of gold. In seven different roastings the loss per cent. of the parts of the metals, was:

of silver	2	11	8	11	23	25	28
of gold	43	43	32	42	62	100	100

The soot recovered from the chimney of the furnace for roasting, submitted in great quantity to repeated assays, for the extraction of gold and silver, gave $\frac{5}{8}$ of a zol. of silver, without a trace of gold for each pood of soot. It is admitted that they obtain annually from the works of K. N. in Altai 120,000 poods of the matt of the furnace, containing nearly 120 poods of auriferous silver, which contains about $3\frac{1}{2}$ poods of gold, and they concluded that there were lost in the roasting about 2 poods of gold and about 11 poods of silver; a very considerable loss for these mines. It was determined then to avoid, if possible, the roasting of all the substances which contain gold and silver.

The chief of the mining staff being returned to Ecatharineburg, made there anew the experiments upon the schlichs of auriferous minerals of Berezofsk, which were submitted to amalgamation raw and roasted; it was demonstrated by these assays:

1. That amalgamation obtained the whole of the gold contained in the schlichs, because the quantity of gold furnished by it was precisely the same as that determined by the assays by acids.

2. That the roasting was objectionable for the amalgamating substances, producing a loss of metal.

3. That this loss, particularly remarkable for gold in matts, affected it preferably to silver; the loss of the latter was elevated to 10 a 32 per cent., and that of the first into 80 per cent.; it was said that after all, probably we might attribute this loss during the roasting of the schlichs in the reverbatory furnace, to the disengagement of vapors and of gas, which carried off the attenuated particles of the precious metals.

To be convinced more completely that the volatile substances

disengage themselves during the roasting of the auriferous matters, carrying the metal with them, M. Varinski made a series of experiments, in which the results confirmed entirely this supposition.

1. Different quantities (1, 2, and 3 poods) of argentiferous martial pyrites not containing any gold, and in which the quantity of silver was determined by assays carefully made, was mixed with 24 zol. of powder of gold, prepared by a chemical method. In each experiment this mixture was roasted upon a tile in a muffle, afterwards it was submitted to scorification and cupellation, and they obtained as a result 14, 16, 20, 22, 26, 37 a 41 per cent. less than the quantity they mixed with the pyrites.

2. Lastly, to demonstrate that the sulphur was not the only substance which in volatilizing itself carried the gold with it, but that there are others which give rise to the same phenomenon, he made a second series of experiments; therefore 24 zolotnicks of powder of gold purified chemically, were mixed with 1, 2, and 3 poods of an ore of iron, containing the oxide of this metal, and water and carbonic acid, but in which there was not either gold, or silver, or sulphur. This mixture was similarly roasted upon a tile in a muffle, and was treated by scorification and cupellation; they obtained by this means from 7 to 23 per cent. of gold less than they had put into the mixture.

3. 24 zol. of gold were mixed with different quantities of pyrites, and of the same sort of ore of iron spoken of before; this mixture was roasted upon a tile in a muffle and treated by scorification and cupellation. The loss of gold was from 4, 6, 8 to 24 per cent.

4. 24 zol. of gold were mixed with a pood of volcanic sulphur. This mixture was submitted to a treatment identically the same as the preceding, but the loss of gold was not more than 4 per cent., probably because the powder of gold smelted promptly, and the vapors of sulphur could not have had time to elevate themselves in particles, as in those which were carried on more slowly.

5. Lastly, to ascertain if this loss of gold operated in roasting in open vases equally as in closed ones, they made the following assays: 24 zol. of gold with the pyrites and the ore of iron were treated by scorification and cupellation, with the preliminary roasting in open and in closed vases. The result of this roasting demonstrated, that when it took place in closed vases the loss of gold was from 16 to 25 per cent., and in open vases from 23 to 29 per cent.

They concluded from these proofs that gold and silver in the metallic state, and which are mixed with substances containing bases which are susceptible of volatilization by the action of heat, volatilizes with them although in different proportions. That the loss affects particularly the metal which is found is the least quantity in the roasted mixture. That the loss is the more considerable as the roasting is the more complete. That in the assays by the dry way for gold and silver, it ought as it appears, to renounce the preliminary roasting admitted until now as a rule, and scorify immediately without roasting, because all of the assays above executed on a small as on a large scale, prove invariably that the roasting produces a loss of the precious metals. When treating a considerable quantity of ore, and of products containing silver, and above all, gold, if it is possible, avoid the roasting. Lastly, it would be desirable that this object should be examined with great care, by means of assays executed in different localities and under different circumstances, upon different substances containing gold and silver, for the purpose of ascertaining if the loss

of these metals during roasting, is effectually as considerable as is shown in the above experiments, and what would be the means of avoiding it in the treatment by fusion and by amalgamation.

Table relating to the Roasting of the Matts of the furnace in the works of Bamarul.

No. of the Roasting.	Poods.	Holding of auriferous silver per pood of matt.	Holding of gold contained in each pound of silver.	Holding of gold per pood of matt.	Total of auriferous silver	Total of gold. They obtained at the end of the Roasting.	Poods	Holding of auriferous silver per pood of matt.	Gold contained in each pound of silver.	Gold in each pood of matt.	Auriferous silver.	Gold.	Total of the loss of argentiferous silver.	Total of the loss of gold.	Loss in 100 parts of silver.	Loss in 100 parts of gold.	Time employed in days.
		Zolotnicks.		Parts.	Livres.	Zolot.		Zolotnicks.		Parts.	Lbs.	Zolot.	Zolotnicks.				
1	500	2½	2⅜	5 1-9	11⅜	27 4-5	517	2¼	1⅜	2 8-9	11⅛	15 7-9	26⅛	12	2½	48⅛	6
2	500	2⅜	2⅛	6½	18⅜	31 7-9	515	2½	1⅛	3 1-6	12	18	157⅜	13⅛	11⅜	43	6
3	500	2¼	2	4 1-9	11	21 3-10	514	2	1⅜	2⅛	10⅜	14⅛	84⅛	6 9-10	8½	32⅛	6
4	500	2⅜	1 8-9	5½	18⅜	27⅛	516	2¼	1⅛	3	12⅛	16	150⅛	11⅛	11⅛	42	6
7	400	2	2⅜	1½	8⅜	7⅛	301	1 8-9			5 8-9		240⅜	7½	28	100	13
5	3000	2⅜		6⅛	74 1-5	200½											
						Well roasted	1.608	1⅛			23 1-6						
						Badly roasted	1.147	2⅜	2⅜	6⅛	28¼	75	17lb.64¼	125 1-6	23 4-5	62½	37
6	250	2	5 3-96	1 1-12	5 1-5	2 6-9	212	1⅜			4		120¼	2 8-9	25	100	8

1, 2, 3, 4, 7, were roasted in a furnace; 5, 6, were roasted in the open air. The roasting of the matts. 1, 2, 3, 4, was done in the same manner as is commonly practised; that is to say, the matt which was employed was such as came from the furnace; they did not consider consequently this roasting as perfect, for the matt being thick was not roasted only on the surface. In the roasting of No. 7, they broke the matt in small fragments, and stirred it without cessation during the roasting to enable the flame to envelope it on all sides. The matt obtained in this manner did not differ in a single point in exterior appearance from the assays in the laboratory of those which had been roasted in the open air.

I think it will be conceded by those who read the above interesting article, that it clearly demonstrates the impracticability of roasting the auriferous ores. The plain matter-of-fact style of narration renders any comments entirely unnecessary.

(To be continued.)

ART. III.—THE SILURIAN SYSTEM; ITS BASE IN MASSACHUSETTS.*

The Secretary read the following communication from Prof. Wm. B. Rogers:

"So far as I have yet explored the quarry in the Quincy and Braintree belt, containing the remarkable fossil Trilobites to which I referred at the preceding meeting of the Society, I find that they belong chiefly, if not altogether, to one species, which on the authority of Agassiz, as well as my own comparison with Barrande's descriptions and figures, is undoubtedly *a Paradoxide.* Of its specific affinities I will not now speak further than to remark that the specimens agree more closely with Barrande's *Par. spinosus* than with any other form.

As the genus Paradoxides is peculiar to the lowest of the paleozoic rocks in Bohemia, Sweden and Great Britain, marking the *Primordial division* of Barrande and the *Lingular flags* of the British survey, we will probably be called upon to place the fossiliferous belt of Quincy and Braintree at or near the horizon of our lowest paleozoic group, that is to say, somewhere about the level of the Primal rocks, the Potsdam sandstone and the Protozoic sandstone of Owen, containing Dikelocephalus in Wisconsin and Minnesota.

Thus *for the first time we are furnished with data for fixing conclusively the paleozoic age of any portion of this tract of ancient and highly altered sediments*, and what is more, for defining in regard to this region the very *base of the paleozoic column*, and that too *by the same fossil inscriptions* which mark it in various parts of the Old World.

One of the most curious facts relating to the trilobite of the Quincy and Braintree belt, is its seeming identity with the *Paradoxides Harlani* described by Green in his monograph of North American trilobites. This description, which is quite imperfect, was made out from a specimen of *unknown locality*, procured some twenty-five years ago, through Dr. Harlan, from the collection of our well-known mineralogist, Mr. Francis Alger. The identity is, I think, established by the comparison of a nearly complete specimen of the Braintree fossil with the cast of P. Harlani, taken from Mr. Alger's specimen, the original never having been returned. Considering the perfect agreement in lithological character of the matrix as described by Green, with that of the Quincy fossils, and the immediate recognition of this agreement in mineral features by Mr. Alger, on seeing my Quincy specimens, we can hardly doubt that the original specimen of P. Harlani came either directly, or through the drift scattered in the vicinity, from the same fossiliferous belt.

Dr. Jackson presented to the Society a cast of a very perfect

* Boston Society of Natural History.

specimen of a Trilobite (Paradoxides Tessini or Harlani) which was obtained by him from the slate quarry at Braintree on the 9th August last. He also exhibited a cast of a specimen of the same species, which from the character of the rock was undoubtedly obtained from the same ledge, and which was purchased by Mr. Francis Alger at the breaking up of the old Columbian Museum of Boston, some twenty-five years ago, and was originally presented to that Museum by some one residing in this vicinity. Mr. Alger's specimen is in a sharp angular prismatic mass of rock, having all the appearances of having been broken from the rocks in place, and certainly was not a boulder.

From the existence of this specimen, and also from the frequent discovery of fragments of trilobites in the erratic rocks on George's island, Geologists were prepared for the discovery of them in some of the ledges of this neighborhood, but no one ever thought of looking among the pinched-up and metamorphic slates between the Quincy and Braintree sienite hills for any fossils, until they were actually disclosed by the quarrying operations of the Messrs. Haywood at Braintree, and one of our members, Peter Wainwright, Esq., recognized them as trilobites and as subjects of great scientific interest, and called the attention of professed Geologists to the locality.

About five years ago, Mr. Eliphas Haywood first observed these fossils on opening his stone quarry for the purpose of obtaining underpinning and ballast stones. Without knowing their nature, he still looked upon them as interesting curiosities, and laid aside the specimens which have lately been brought before the Society.

He showed them to Mr. Wainwright, who at once recognized them as trilobites and brought them to Boston for the inspection of Geologists, and presented two specimens to our associate, Prof. Wm. B. Rogers, to whom the Society is indebted for the first notice of these remarkable fossils, so important in the determination of our geognostic horizon. A few days after Prof. Roger's visit to the quarry, Dr. Jackson, by invitation of Mr. Wainwright, visited it and made a minute examination of all the geological phenomena which it presents, and obtained specimens of the trilobites through the kindness of Mr. Haywood, and by search at the quarry in company with Mr. Wainwright. Two specimens were obtained, one entire, which is 8½ inches long and 4 inches wide.

The other, of which only the head and half the body was obtained, is 6 inches wide, and its hood is 7½ inches across by the base of the head; hence the length of this specimen must have been 12½ inches at least, which is about the size of the largest specimens of the Paradoxides Tessini discovered in Sweden. The smaller individual has 21 articulations, but none in the tail beyond the lateral appendages, and in this respect differs

from the P. Tessini, its nearest analogue, which has, according to Brongniart, four faintly marked depressions or folds crossing the tail transversely. They may have been obliterated in our specimen by the changes the rock has undergone. These trilobites of Braintree occur in a blue gray argillaceous slate, containing silicate of lime, but no carbonate, and some disseminated iron pyrites. The stratification of the rock, as indicated by its grain and cleavages, dips to the north 50°, and runs east and west. It is but slightly altered by heat in those portions where the trilobites are found, but near the sienite rocks it is filled with nodules of epidote, and closely resembles the altered slates of Nahant. There is a small vein of quartz, bearing iron pyrites in it, which cuts through the slate strata at right angles. There are also slickensides surfaces on some of the cleavages or joints in the quarry, indicating, as it is supposed, the polishing effects of rapid earthquake movements at the period of disturbance of the strata at the time of their disruption by intruded sienite.

These are all the marks discoverable of metamorphic action of igneous rocks on these sedimentary strata, though the slate rocks are hemmed in by the sienite rocks on both sides, and the belt of slate is quite narrow.

On a hill near the quarry he could see the tall steeple of the Baptist church in Somerset street, and on taking its bearings with the compass, it was found to be N. 10° W., and Nahant would be a little to the East of North. The Braintree rocks would then dip under those of Nahant, unless the same formation extended across the bay, and the Nahant series would form its upper strata.

The existence of these Paradoxides in the argillaceous slates of Braintree proves them to belong to the lowest of the fossiliferous silurian rocks, and that they are the geological equivalents of the argillaceous slates of Sweden, which are in a similar manner disrupted by the intrusion of sienite. It is certainly interesting to find the base of the Silurian system resting within the limits of old Massachusetts.

ART. IV.—REPORTS AND EXPERIMENTS ON THE STRENGTH AND OTHER PROPERTIES OF METALS FOR CANNON, WITH A DESCRIPTION OF THE MACHINES FOR TESTING METALS, AND OF THE CLASSIFICATION OF CANNON IN SERVICE.—By OFFICERS OF THE ORDNANCE DEPARTMENT U. S. ARMY. By Authority of the Secretary of War. HENRY CAREY BAIRD: Philadelphia, 1856.

THE question "*What is the best material for the military arm of a nation?*" is one of national and *vital* importance: because the

demonstration of the war aspect of the question gives us corollaries for the determination of points essential in the arts of peace. Our government, in experimental science, is certainly ahead of European ones; and the solution of this national question engaged official attention many years since. The work (the title of which precedes this article) is the result and deductions of long and practical series of experiments alike creditable to our government and the officers and gentlemen co-operating in the investigation. This work, also published by Trübner & Co., London, is evincive of the fact that it is appreciated abroad; and we know it has received the most favorable critical notices from the scientific and practical periodicals of Europe. It is quoted in military and naval journals as standard authority, and has aroused a similar spirit of investigation in several European governments; and as the ball rolls on we may hope for some splendid deductions of applied science and an augmentation of mineral economic wealth.

We leave to the military journals to discuss and illustrate, if they can, the position that the *amelioration* of the savageness and miseries of war is increased by the improvement and increased destructiveness of weapons of war—and that by the assured certainty of destruction of life—the less will be the ultimate loss of it; or, in other words, the moral certainty of death will increase the moral aversion to exposure to it. While we thus avoid a discussion of this question, we do not hesitate to say, that such experiments and trials have a *moral aspect* of the highest character. The elimination of the elementary composition of metals for war purposes cannot fail in presenting facts and corollaries of essential value in the arts and commerce of life. In its utilizing and peaceful character, we propose to add our commendation of the great practical value of this work.

The investigations were commenced nearly simultaneously with the organization of the Ordnance Corps, and the earlier results were published in the "Ordnance Manual" of 1840. The volume before us gives us a series of most interesting reports commencing as late back as March, 1844. We are glad of the opportunity in this place to add our testimony to the great value of our West Point Military Academy in its contributions to the exact and applied sciences of our country. For whatever exactness and profound and critical analysis this volume affords us in these experiments, we may trace to the influence of the system of instruction maintained in that noble and national Institution.

The earlier investigations were mainly directed to the manufacture and patterns of guns, and the methods pursued at the different foundries in Europe and the United States. From these investigations it was ascertained that of a series of guns made of the same material, pattern, and identity of process, some would bear the maximum test without injury, while others supposed to

be exactly, and in all respects like them, would not bear proof charges, or failed after a few rounds. The failure then was not due to the material or its treatment during the process of manufacture, but to a cause remote, and not ascertained, but supposed, from the facts elicited, to be in the *ore* from which the iron was made.

We should here premise that one result of the experiments was that *cast iron* was the safest and best resource for heavy seacoast siege and garrison cannon; and for the lighter field-pieces it was resolved to adopt bronze as a material least likely to burst into fragments.

For the purpose of ascertaining the variety of influences arising from the varieties of the crude material or ore, or, in the language of the report, "to determine the causes which so materially affect the quality of gun metal," a laboratory was established at Pekesville, and in it every means was adopted to insure accuracy and completeness in the results. It was devised with a view to the qualitative and quantitative examination of each specimen, and was so arranged that any *ingredient existing in gun metal*, even in minute proportions, could not escape detection during the process of manipulation.

From these experiments and tabular deductions, it seems that the *total* carbon proves nothing in favor of its influence upon the quality of the iron, although further examination may, perhaps, modify this conclusion. There is, however, a decided relation of the carbons in their separate states to specific gravity and tensile strength. Allotropic carbon increases, and the combined carbon decreases; and this excess of allotropic carbon must exist as graphite or black lead, which is injurious. The extremes of the amount of carbons as affecting the increase or diminution of the excellence of the quality of the metals, their influence upon its molecular construction, and the possibility of their being replaced by some other ingredient, are matters of great importance, and still under investigation. In the table exhibiting the effects of *hot and cold blast*, it appears the hot blast has driven off a portion of carbon from combination, so that the *cold blast* metal contains two and three-fourth times as much combined carbon. The hot blast metal, however, meets with some compensation for this loss of carbon by reducing by its intense heat a larger amount of silica, and assuming silicium. The hot blast contains nearly four times as much slag as the cold blast: and the slag and allotropic carbon being of a brittle character, and not uniting with the iron, coat the crystalline plates of metal, and diminish the surface contact, and consequently tensile strength—which strength is also further diminished by the replacement of carbon by silicium. The average specific gravity of the *hot blast* iron appears to be 7.065, and the tensile strength 19.640. The average specific gravity of the cold blast was 7.218, and the tensile strength 29.219. The ex-

traneous matters found in combination with the iron were allotropic carbon, combined carbon, silicium, calcium, magnesium, sodium, potassium, cobalt, nickel, manganese, aluminium, copper, phosphorus, tin, titanium, antimony, sulphur. On this point of the relative value of hot and cold blast iron, the general deduction thus far appears to be that the hot blast is inferior to cold blast, by reason of the relative excess of slag and allotropic carbon.

The ores of iron contain that metal in the state of oxide, accompanied more or less by earthy matter. *These oxides are the magnetic or protoperoxide, and containing, when pure, the highest amount of metal.* The *peroxide*, which when crystalline is called *Specular*, and Red Hematite when earthy—the Hydrated Peroxide or Brown Hematite—Bog ore and Pipe ore; the carbonate of the Protoxide. which when crystallized is sparry, and when earthy is the coal ore, or clay ironstone.

The best practicable division is based upon the largest amount of associated matter. 1st. *Silicious*, with *silica* as the earthy constituent, including most of the magnetic and specular oxides. 2nd. Calcareous, which are usually very silicious, and include the Red Hematite. 3rd. *Magnesian*, with Talcose gangue of magnesia and silica, and the iron as *magnetic oxide*. 4th. Argillaceous, containing *alumina* and *silica*, and include the earthy brown hematite and clay iron stone. 5th. *Manganesian*, including the sparry and brown hematites.

In reducing iron ores the oxide is reduced to metal, and its associates are fused into slag or cinder by the use of limestone as a flux. *All the ores* contain *silica;* but when it is alone, or associated only with lime or magnesia, as in the first three classes, the fluxion of the earthy matter, and consequent reduction of earthy constituents, is attended with difficulty. Hence, such ores are termed *hard;* on the other hand, when the *silica* is associated with alumina or oxide of manganese, as in classes four and five, the slag is more fusible, reduction facilitated, and the ores called *soft*.

The ores of the second class (calcareous) are often so very calcareous that the use of limestone as a flux is unnecessary and injurious. In such cases where an argillaceous or manganesian ore is not to be obtained, the addition of clay itself renders them more easy of reduction, and the clay may be regarded as a flux.

As a general rule a single ore *rarely* contains the ingredients in due proportion required to flux it readily, and hence the utility of mingling different kinds of ores. Either of the *first three* may be advantageously mixed with either of the two latter classes.

The process of reduction is as follows: The ore, flux and fuel being thrown together into the top of the furnace, gradually descend, and the first operation to which the ore is subjected is reduction. *Carbonic oxide gas* arising from the combustion of

the fuel in the lower part of the furnace, reduces the oxide of iron to the metallic state. The next operation is the union of the flux and earthy matters into a fusible and flowing *slag*, by which the reduced metal becomes exposed to the cementing action of carbon, and forms with it fusible *carburet of iron*, or cast iron. The fused metal and slag flow drop-wise to the bottom of the furnace, where they collect into two strata, the heavier metal below being covered by the lighter slag above it. The slag is drawn off from time to time until the accumulated metal rises to the top of the dam-stone, when it is run into pigs.

The actual influence of the associates of ores upon the cast-iron has after all been only measurably determined in a comparatively few cases as yet—e. g., *Manganese* imparts a large camellar and brilliant fracture; phosphorus renders iron "*cold short*," and *sulphur* "*hot short*." No search was made for *nitrogen*, as its presence was admitted by careful experiments. The report doubts the presence of oxygen as an essential ingredient of recently made metal, except in the minute portions of the slag accidentally remaining in it, and which sometimes contain a silicate of the oxide of iron. *Aridium*, said to have been found in some Swedish ores, was not observed.

The inequalities of bronze guns appear to arise from defective homogeneity, caused by a division of the alloy.

It is the opinion of some chemists that melted bronze separates into two or more distinct alloys while cooling, each combining different proportions of copper and tin, and forming separate and definite chemical compounds. One of them combining the largest portion of copper with the least portion of tin, will form an alloy having a higher melting point than another, which combines a larger portion of tin. The former will crystallize, and become solid; while the latter, being more fusible, will remain a longer time in a liquid state. This opinion appears to have been verified by the experiments. The alloy which exuded at the upper surface of the casting was evidently quite different from the remaining mass, it being a much lighter color and containing a much larger proportion of tin. Its separation appears to be caused by the gases generated in the mould in the process of casting. As these gases cannot escape through the compact mould, they ascend through the spaces made vacant by the contractions in the crystallized mass, and force along with them and expel the more fusible alloy.

The division of the copper and tin into two or more separate alloys probably occurs at some definite temperatures. One division may occur in the liquid mass, and another after the temperature falls below the melting point of copper.

From the series of experiments it would seem that the injurious consequences of casting at a high temperature are limited to castings of a large mass.

Another set of experiments afforded as a result, that in every instance the *transverse strength is augmented by rapid cooling*, and that tensile strength is increased by slow cooling in large masses, the differences in specific gravity being less marked; but it is somewhat higher in the small castings cooled rapidly. (Tensile strength of iron is its power to resist being torn asunder by a force applied in the direction of the length of a bar.)

The experiments to ascertain the relations of density and specific gravity in bronze castings developed some interesting facts, one of which we note in the case of two 12-pounder howitzers. They were both cast at the same melting. The metal was drawn from the furnace into a ladle, and from that poured into one of the moulds. The ladle then was replenished from the furnace, when the other mould was filled—the interval between the castings was 8 or 10 minutes. The difference in density was $3\frac{1}{3}$ per cent. or about 18 pounds to the cubic foot. A greater difference was discerned in the density of different parts of the same casting, as great as $5\frac{1}{2}$ per cent. or 28 pounds per cubic foot.

In some of the experiments, a great difference in the endurance of iron guns, particularly those cast hollow, was attributed to the different methods of cooling the castings; and the facts elicited some very incongruous results, involving for explanation the laws which control the contraction of iron when cooling.

According to Danrill, the linear expansion of cast iron between 62° and *its melting point* (2786°), is .016389; equal to $\frac{1}{61}$ part of its length. The contraction under equal reductions of temperature is different in iron of different qualities. Soft gray iron containing a high proportion of carbon contracting least; and that which foundries term *high*, and which is hard, light, close-grained, containing the least percentage of carbon, contracts the most, ceteris paribus. The contraction is also modified by the greater or less rapidity in cooling. This contraction when unequal creates a strain; and in the case of cannon, this strain is exerted in a direction tending to assist the central force of the charge in bursting. *The exact measure of the consequences of such strains*, is the problem yet to be solved.

The effect produced by *re-melting* iron, and by retaining it in fusion exposed to an intense heat, is exhibited in the following results, which are extracted from the tables of the reports:—

	Density.	Tenacity.
American pig iron, first fusion . . .	6.948	11.420
Same iron re-melted, 6 hours, in second fusion .	7.172	26.810
Another parcel Amenia iron, second fusion .	7.184	26.237
Same iron re-melted, cast in guns, third fusion .	7.322	34.728
Another parcel Amenia iron, second fusion .	7.070	16.783
Same iron re-melted, cast into guns, third fusion .	7.326	34.465
Brigg's furnace iron, first casting of second fusion	7.112	15.729
Same iron, last casting, re-melted after 8 hours additional infusion, third fusion . .	7.391	34.599

We would suggest to those engaged in the investigations of the chemical and mechanical relations of iron, that some attention be paid to the influences of the electro-motive energies of the ores or metals examined upon each other. The agent termed electricity is distributed in bodies throughout the world in quantities proportioned to their attractions for it; in other words, bodies have different electrical capacities, and electro-magnetic action is undoubtedly determining axes of force in molecular arrangement. In our coal measures the associated iron is always a carbonate, and when in contact with the coal, a sulphuret. The influence of these ores upon the needle is measured generally by their quantitative presence. But this fact has been ascertained, that where other things being equal the quantitative presence is the same, but the subjacent coal has approached nearer the rock bearing carbonate, and that coal at the same time undergoing a process of crystallization, the magnetic force has caused a vertical action of the needle of such intensity as to prevent all horizontal motion: and these *dips* were most frequent, the nearer the needle was to the crystallizing process in the coal.

The influence of high rotative forces in evolving magnetic action, and producing molecular disturbance, has been assigned as the cause of the destruction and disintegration of the molecular contact, or of the tensile and tortural powers of railroad axles. The graphitic or allotropic character of the grains on the fractured surfaces of the axles is well known. Now, without starting a theory, we would suggest the inquiries of what may be the influences of such elements immediately in the ores—collaterally in the temperatures attendant upon reduction, and ultimately in the metal.

We cannot find room for any more quotations from this valuable work. Every page is replete with valuable information, and suggestive of continued and unwearied investigations on the part of our iron masters.

Iron, it must be remembered, is the pabulum of our domestic and commercial life; and in these relations the quantitative value of its ores is not the measure of the economic value of these relations, but it is the mode, facility, and cheapness of its reduction. We have recently seen statements of the cost of reduction from ore to pig metal in some furnaces on the Ohio and Mississippi rivers and vicinity, as low as $10 per ton, these statements being made by reliable men. We have also seen equally reliable statements by our New York, New Jersey, and Pennsylvania iron masters, that good iron cannot be made for less than $17 per ton, all the circumstances of ores and fluxes being ratably equal.

We apprehend both statements require modification, and that *management* and *terms of credit* customary in the part of the country where the iron is made, has much to do with the cost.

No locality, and no facility, will yield cheap-made iron where the *management is bad.* On management every thing depends, and *sciolism* has blown out more furnaces in our country than over fluctuations of market have done. Where credits on sales are long, more working capital or larger commissions are required, and a correspondingly large interest account. We hope our readers will procure this work (the place of imprint being seen on the half title to this article), and that they will arise from its perusal as deeply impressed with its value as ourselves.

ART. V.—THE MINING OF COAL, &c., &c. By A. T. PONSON. No. 7.

[Continued from page 265, Vol. VII.]

102. *Exploration of the Continuity of Seams and their Succession, means of Shallow Boring.**

As the whole of a deposit can be known only by a series of borings, which, being shallow, are sometimes more economical than a single one carried to a greater depth, it is proper to present here an example based upon an indefinite number of borings. Suppose, then, that in searching the extension of a basin, we find, by means of the boring No. 1, situated almost in the axis

* The following statement or list of English patents which have been taken out for Earth Boring Machines, is from a paper read by David Chadwick before the Manchester Literary and Philosophical Society:—

This list contains the names of James Ryan, who took out a patent in 1805; John Goode, 1823; Robert Breart, 1844; Wm. and Colin Mather, 1845; Wm. G. Gard, 1847; Charles Gotthelf Kind and Charles Alexis de Wendel, 1850; William Edward Schottlander, 1852; John Worthington and Fennel Allman, May, 1854; and Colin Mather, October, 1854. In addition to these may be mentioned many well known well-borers, although their improvements are not patented in this country, and amongst them Easton and Amas, and D. Greenley, London; Fauvelle, Perpignon; J. F. Lane, Wilderz, Switzerland; Mulot and Son, Paris; and John Thompson, of Philadelphia.

M. Breart describes certain improvements, by which the earth cut by the boring tools at the bottom of the shaft shall be immediately removed by a stream of water, in order to prevent the necessity for so frequently raising the boring rod. He proposes to pass water down a hollow syphon pipe from a small reservoir at the top, so that as the water ascends the other limb of the syphon it may bring the particles of earth to the top. There are evidently many difficulties to be overcome in this plan, and as it does not appear to have been much used, they have probably been found to be insurmountable.

Messrs. W. and C. Mather's improvements of 1845 consist of a new arrangement of cutting tools in a boring head. A shell-pump, and a new method of giving a percussion motion to the boring instrument by means of a flattened rope round a winding drum, and actuated by a piston of a steam-engine.

Mr. Gard's improvements consist in using a cylindrical shaft, with cutters

of a basin, five seams *f*, *g*, *h*, *i*, *k*, and their inclination and the nature of the inclosing rocks—let it serve to form a transverse section of the series, in order to assure ourselves of their conti-

attached, made with a single bevil, inclining inwards; above the cutters is a ball valve, fitting into a circular aperture, and so arranged that when the machine is worked the borings are forced through apertures up the cylindrical shaft above the cutters, and pass the ball valve, which brings the whole to the top. This machine is worked by a rope, or chain, run round a fly-wheel.

Messrs. Kind and de Wendel's improvements consist of—1. A novel construction of boring tool. 2. A method of withdrawing a clod of earth, to ascertain the nature of the soil at any required depth. 3. A compound boring tool for shafts of large diameter. 4. A scraper for striking the soil to the centre of the tool. 5. Improvements in boring shafts of a cylindrical form. by the employment of oak cylinders and iron. The former are constructed like barrels, and retained in their proper position, one above the other, by broad rings or hoops of iron; and the latter have internal flanges, by which they are bolted together. By an ingenious arrangement of flanged teeth solid cores of hard material are bored, and brought to the surface. This machine is extensively used on the Continent, and its use has effected a considerable reduction in the cost of boring for mining purposes and geological research.

Mr. W. E. Schottländer's patent (a communication) consists in the use of boring-rods, fitted inside hollow cylinders—the boring tool being of a screw shape, and so attached to the machinery at the top of the well as to receive, by the turning of a winch-handle, a rotary motion round its axis, at the same time as it is progressively forced downwards. Additional rods and hollow cylinders can be attached as the boring increases in depth. For the purpose of removing the core of earth from the interior of the boring-rods, a double set of pipes may be employed, the inner ones being cleansed and returned.

Messrs. Worthington and Allman's patent claims the use of any kind of drills, bits, or tools, for boring when they receive a rotary or reciprocating motion. and the making of bits, drills and boring tools, partly of iron and partly of steel, to prevent the necessity for frequent sharpening. The first and most important part of this patent is the same as Schottlander's.

M. Fauvelle's improvements were described in a paper written by M. Arago, and read by Mr. Vignoles, at the meeting of the British Association in 1846. The apparatus is composed of a hollow boring rod, formed of wrought iron tubes screwed end to end. The lower end of the hollow rod is armed with a perforating tool, suited to the character of the strata. The upper end of the hollow rod is connected with a force pump by jointed or flexible tubes, which will follow the descending movement of the boring tube for an extent of some yards: the boring tube is worked by a rotary movement, with a turning angle, or by percussion with a jumper; the frame or tackle for lifting, lowering and sustaining the boring-rod are of the common kind; a column of water is sent down by the pump to the bottom of the bore hole, the water rising in the annular space between the exterior of the hollow boring-rod and the sides of the bore hole creates an ascending current, which carries up the triturated soil. The boring tube is worked like an ordinary boring-rod; there is, consequently, no occasion to draw up the boring tube to remove the debris, and the boring tool never gets clogged by the soil.

The jurors of the Great Exhibition of 1851 drew particular attention to the boring tools of Mr. J. F. Lane, of Wilderz, Switzerland. Water is introduced by means of hollow rods, and mixing with the powder or small dust formed in boring, is discharged through the tool by the blow of the latter in descending, keeping the bottom clear, and ready to receive the full effect of the tool. A boring of 1,300 feet has been made with these tools, and with a facility of which the old tools are not susceptible.

Mr. John Thompson's improvements consist of a cylindrical iron bar,

nuity and succession, following their inclination, that is to say, according to a line running north and south—we begin at first by calculating, supposing the deposit to be very regularly stratified, at what distance should be made borings of equal depth, in order that each one should strike in its course with the first or the last seam, already made known by the first boring? Thus, for example, *k* having been pierced by number one at a depth of 80 metres, the inclination being $\frac{1}{10}$ c., we conclude that No. 2 should be bored at least 800 metres from the first, if we wish to meet again towards the surface of the ground the same seam *k*, and thus put the two borings in relation. We obtain by this new pit a knowledge of lower strata deposited at a depth which would have been reached if No. 1 had been carried to 160 metres

nearly filling the bore hole, about 5 ft. long, to the bottom of which is attached a chisel for drilling. On the top of this cylinder is a swivel, with a square iron bar, about 4 ft. long, and 1 in. each way passing through an elliptical steel spring, and fixed to a rope. The elliptical spring is of four strips, 18 or 20 inches long, and embraces the side of the bore hole. The lower disc has a round and the upper a square hole for the bar to work in; the spring acts as a brace by pressing outwardly, and remains in a fixed position while the machine is at work.

The following is a statement of borings recently made by Kind's system on the Continent, as furnished by Mr. Herbert Mackworth, C.E. :—

Localities.		Diameter of bore ft. in.	Depth in Yards.	Time in days of 12 hours.	Cost of labor and material per yard.
At Montmorot Jura,	No. 1	0 12	164	84	£0 19 8
ditto,	No. 2	0 12	185	112	1 2 0
ditto,	No. 3	0 12	309	in progress.	
At Stiring Moselle,	No. 1	0 12	327	354	0 19 1
ditto,	No. 2	0 12	355	422	1 0 11
ditto,	No. 3	0 12	295	330	0 19 8
ditto,	No. 4	4 0½	120	216	1 4 4
At Guineas Pas de Calais		0 12	268	86	1 1 9
At Vizernes, ditto,		0 12	159	87	1 0 7
Boring 764 yards deep.					
At Mondorff, Grand Duchy of Luxembourg	old system	0 10	371	37 months	5 1 0
	new ditto	0 10	393	14 months	2 2 0

The following is a list of some deep wells, executed by Mr. D. Greenley, of London:—

1832—Taylor and Dyson's Brewery, Diss, Norfolk	Depth	596	feet
1835—Sir Joseph Fuller's, Ruislip, Middlesex	„	312	„
1835—Messrs. Duncan, Taplow, Bucks	„	312	„
1839—Sir R. P. Glynn, Wimbourne, Dorset	„	306	„
1844—The Corporation of Ruthin, North Wales (the town well)	„	419	„
1847—Messrs. Jennings' Brewery, Windsor, Berks	„	520	„
1849—Gerald Fitzgerald, Esq., Burfield, Berks	„	392	„
1851—L. Davis, Esq., Plumstead Common, Kent	„	552	„
1854—Her Majesty's Dockyard, Chatham	„	610	„

The author then refers to Mr. Colin Mather's invention, and which he considers most valuable, and likely to cause great practical improvements to be introduced and adopted in all deep cuttings; and, in conclusion, observes that well sinking and earth boring will, under various circumstances, present many difficulties; and the engineer will be required to have a large amount of practical knowledge, not only of the various strata through which he has to cut, but of the most suitable boring tools to be used in each case.

instead of 80 metres. We should take care during the boring to observe all the remarkable beds, among others those of sandstone suitable to furnish the last most important indications. Other borings should be undertaken on the north along the line, until the sound brings up the anthraxiferous limestone, or some other rock older than the coal series. If, for example, beyond No. 2, we make two others, the result will be almost the same as if No. 1 had been pushed to the depth of 320 metres.

The distance comprised between two consecutive borings given by the calculation, is only an appreciation modified by the explorer following considerations arising from the character of the surface; thus he avoids boring upon eminences, and seeks as far as possible the bottom of valleys, ravines, &c.; thus a boring of an average depth enables him to reach seams for which he would be obliged to bore a great depth if he worked on the summit of a hill.

He will next proceed southerly in order to find the upper seams and their supposed elevation, towards this point of compass. If, for example, having commenced No. 3, this boring, instead of traversing many stratifications hitherto unknown, immediately encounters the seams *f*, *g*, *h*, already traversed by No. 1, it is still continued some time; but the certainty becoming complete of meeting the beds of sandstone, it is abandoned as not likely to afford any information not already possessed. He concludes from this circumstance, that the two pits are separated by a fault sinking the seams on the north a depth easy to calculate, and of which the elements are the inclination, the depth at which the same seams are found in the two pits, and the distance which separates the boring spots.

Continuing the exploration toward the south, No. 4 is made; it furnishes a knowledge of five seams *a*, *b*, *c*, *d*, *e*, heretofore unknown, and of which the inclination has diminished; we continue the boring until it reaches the same strata as *f*, *g*, which leaves no doubt of their relations with No. 4; and as they are found at a greater depth than one would have expected from the inclination of the series, we conclude that there exists likewise a derangement between the two borings, the extent of which is easily calculated.

In short, No. 5 shows that the seams in rising southerly have a considerable inclination; in this case, the borings should approach each other, unless we prefer to dig, which cuts all. The local circumstances and the future wants of the working alone determine the means which should be adopted.

We perceive now how derangements can cause difficulty in a reconnoissance of a formation; often the height of upheaval of a fault between two borings is such that it is impossible to reach a stratification already known; the sound descends into the stuff that has filled the fissure and brings up no result; sometimes,

also, two seams of different coal, although of the same puissance, correspond on the two sides of a rupture of the series, in such a manner that the most experienced miner is naturally led to erroneous conclusions. A careful examination of the enclosing rocks, or an exploration by pits and galleries alone is sufficient to rectify the errors committed in the borings. Nevertheless, we can thus advance from east to west, and traverse a series of perpendicular sections, at a direction previously known.

103. *Samples and Journal of the Borings.*

The stuff brought to the surface by the tools should be treated with caution, since it is the only guide which can lead the workmen to a just appreciation of the rock traversed. He will proceed prudently by not placing all confidence in the debris brought up by the trepan, for this is always mixed with the dirt accumulated at the bottom. The augers are evidently the best tools for bringing to the surface the most pure samples; but all parts of the *carotte*, that is, the cylindrical mass of stuff, are not found to possess an equal degree of purity; the lower portion only can give sufficient confidence, for the instrument, penetrating into the virgin strata, brings up every time a greater or less quantity which forms the base of the *carotte*, and furnishes the core unmixed. The clayey detritus is dry—the fragments of schist and sandstone are washed, in order to be cleansed of the dirt which surrounds them; if they are heterogeneous, the greatest number of the same kind indicate the nature of the rock traversed. As the most voluminous debris expresses with the most exactness the nature of the beds traversed, it will be easy to obtain every time sufficient to judge. At this point, some use a trepan by which a cylinder is formed at the bottom, which, broken afterwards by the ordinary trepan, will yield convenient pieces which the valved auger will bring up. We can proceed equally well inversely, that is, by making at first a cavity with a trepan of small diameter, and afterwards breaking the circumference with a tool of equal diameter with the sound.

All the parcels of the series obtained at different depths are classed in a case, the numbers of which correspond to the numbers inscribed in the columns of the journal of the boring. This list usually comprises—1st. The date and hour of the various manœuvres. 2nd. The depth from which the sample was extracted. 3rd. The kind of tool used. 4th. The number of the rising of the sample. 5th. The designation of the rock traversed. 6th. Its degree of hardness. 7th. The estimate of the thickness of the beds. 8th. A column of observations, in which are written the smallest details that can, sooner or later, be of any interest.

104. *Verification of the Borings.*

If, unfortunately, confusion should occur amid the samples

of a boring which has been completed, if it becomes useful to examine anew the nature of certain strata lying at considerable depth—if, in short, it is necessary to examine again the puissance of a bed of coal, or of a bed of sandstone, respecting which some doubts have arisen, an instrument called *verificator* of a boring is used.

The instrument of this kind generally used, conjointly with the rigid stem, is an ordinary "widener," armed with ears or toothed pinions, beneath which is adjusted a capsule or cup, suitable to receive the fragments coming from the tearing of the walls. In order to use the *verificator*, it is turned as it is let down, in an opposite direction from that in which it is worked, so as to prevent the teeth from getting fast. As it arrives at the strata to be examined, some sharp, jerking motions are given to it, which clears the teeth, so they open completely and fasten to the strata; and then by the circular movement which is given, they tear the walls, and the debris falls into the capsule.

To verify the vertical height of a seam, or of any other bed, we place the instrument about in the middle of the stratification. At every trial it is raised or let down two or three centimetres until the debris does not contain any coal or particle of the rock which is the object of examination. If the two extreme points have been marked upon the rod, the space which separates the two traces will express the vertical distance comprised between the upper and lower plane of the stratification.

There is a tool of this kind used for a verification of the soundings with a cord; the teeth are arranged vertically, and move round a horizontal axis in such a manner that the samples are detached from the walls when the instrument is made to *sound;* but this *verificator* is involved with springs, and composed of a great number of pieces, and is far from offering the facility to operate and the exactness of results furnished by the former one.

105. *Exploration by Pits and Galleries.*

The series in which the strata approach a vertical position cannot be explored by boring; the tool is constantly retained in the sterile beds interposed between two seams, or at least reaches only a very small number of them. The boring instrument should be directed horizontally; but the length of the horizontal boring, ordinarily very limited, is altogether insufficient; besides, it is very rare that the strata are suitable for an operation of this kind. Under such circumstances it is necessary to resort to pits and galleries, or to a combination of these two methods of excavation.

The work will consist simply of a gallery, if the surface of the series, being greatly broken, presents hills very elevated above the valleys; or if some depression of the series, such as a deep ravine, favors a horizontal opening. In this case the excavation should be made on such a level as not to be exposed to any

inundations from a rivulet or stream flowing in the valley; it will take a direction which is perpendicular to the stratification, to reach the seams by the shortest line, and it should be extended a considerable distance, in order to cut a great number. If we are exposed to traverse a great space of tertiary series, such as sand, pebbles, or other water-carrying strata, if the surface of the ground is level, if there are not found any depressions in aid of horizontal work, we should sink a pit until we reach the coal formation in a normal and regular stratification; then we should dig two galleries in opposite directions—that is to say, one towards the foot and the other towards the head of the seams, and proceed with them equally in the right direction.

It is by means of pits that we know the slightly inclined strata of a deposit previously explored, or regarded as carboniferous. They are resorted to for accomplishing the explorations based upon simple presumptions, the result of a probable extension of a basin of coal. It is thus that, during the year 1734, the Viscount Desandrouin at length discovered the rich mines of Anzin, after 17years of unprofitable labor, and at an expense of more than three millions (francs). Although that exploration traversed the water-carrying series, it was undertaken on no other ground than the supposition of the extension of the seams of Mons.

106. *A Comparison of the two preceding Methods of Exploration.*

There are many advantages, and many drawbacks, to the use of boring for the exploration of mines of coal, and a reconnoissance of the seams. The blame and the praises should be ascribed to the fact that the question has always been investigated in an absolute manner, without regard to local circumstances and to the results proposed to be obtained.

Boring is a more speedy and cheap operation than the digging of a pit or gallery of the same length. Companies, especially, engaged in this kind of enterprise, prefer the former to the latter mode, particularly if the facts previously obtained do not afford sufficiently certain indications; especially, also, if it is possible to foresee the case in which the coal series, being covered by thick water-carrying strata, require, for the making of pits, works of considerable art, the great cost of which may become an entire loss. Many deep borings, or the digging of a single pit, absorb almost equal sums. Now, numerous borings furnish a greater chance than a single vertical excavation to encounter the coal below a given surface, since this excavation attacks the formation only at a single point, and cannot demonstrate the absence of combustible at others.

Such are the circumstances under which boring seems to possess the superiority; but if the pits or galleries opened on an outcrop can penetrate at once into the seam; if they possess the

certainty of being established on a coal strata which is not barren, the diggings can serve, not only for exploration, but for works for future operations; all things then require the use of the second method.

In all cases boring gives more incomplete and insufficient results than an excavation in which a man can enter. We can, it is true, recognize the inclination of the series, and consequently, its direction, by once boring. But how delicate is this operation! and what guarantee is there against all the chances of error? The debris brought to the surface in boring informs the explorer of the quality of the coal. He knows if it is fat or lean; but its compact nature and brittleness are unknown to him; he obtains no information upon the solidity of the roof or foot-wall, notwithstanding the importance of these objects. Whatever may be the precautions he takes, he can rarely assign with exactness the puissance of the seams; he has no idea of the continuity of the deposit, or the relative number of its derangements—in a word, he cannot obtain all the important points as he can by a pit or gallery, nor demonstrate the possibility or usefulness of working a bed. After having established the existence of coal by boring, he must then dig pits and incur double expense.

(To be continued.)

ART. VI.—METALLURGICAL TREATMENT OF THE ORES OF SILVER LEAD, &c., AT THE SMELTING WORKS ON THE LOZIERE, FRANCE. By M. LAN. No. 2.*

[Continued from page 284, Vol. VII.]

THE smelting works of Vialas, surrounded by the shops for the dressing of the ores, consist at the present day of two roasting furnaces, two low blast furnaces, one furnace of cupellation, one furnace for the refining of the silver. A blast machine, worked either by steam or water, serves the furnaces. By the side of this apparatus there is, also, on the right bank of the Picadier, storehouses for the schlich, charcoal, powder, tools, etc., a carpenter's shop, forge, dry stamps for crushing charcoal and the earth for the cupels, compartments for roasted ore, reservoirs for the products, litharge, etc. The ores of Vialas are usually of a very simple composition; apart from the principal element, the sulphuret of argentiferous lead, the only metallic elements which present themselves in any notable quantity, are the sulphurets of iron and zinc. All the veins, and especially all the

* The words "pig lead," on page 284 should read *silver lead*.

parts of the same vein, are not equally rich in pyrites and blende. With regard to the gangue, although the quartz may be the principal element, the sulphate of barytes increases at some points, and sometimes the gangue becomes exclusively schistose. Notwithstanding these causes of difference in the nature of the ores, not only are they subjected to a uniform preparation, but likewise all the washed products are mixed. Besides, in the absence of storehouses, and in the absence of a sufficient moving power, it is impossible to have any considerable amount of schlich.

This, as any one can foresee, should be a cause of inevitable irregularities in the metallurgical treatment.

However this may be, the argentiferous galena of Vialas should be regarded as a quartzose and pyritous ore.

It is this circumstance, joined to some others, of which it remains for us to speak, which determines the formula of the metallurgical treatment.

Considering the abundance of quartz, the treatment at the reverberatory furnace, tried in other times at Villefort, would not be suitable at Vialas; the experiments made in the old foundry have been with products with richer gangue than the schlich of Vialas; but more recent experiments, made in Germany, upon ores of a comparative character, prove that we do not obtain any satisfactory result in the reverberatory furnace with the galena of Vialas. The methods of precipitation, by iron or melting, should likewise be rejected, considering the impossibility of procuring at a fair rate the raw materials; nor is it possible to think of a mixed process, for we cannot procure at a cheap price the scales or slag of the forge.

The distance from the foundry of all the raw materials, which can so powerfully facilitate the treatment; the nature of the ore; such are the circumstances which led to the adoption, and continuance from the outset of the enterprise, of the following formula of treatment:

1.—Complete roasting of the ore; separation of the sulphur and its components; agglomeration.

2.—Fusion and reduction under the sole influence of fuel.

The silver lead obtained by these two successive operations is finally cupelled for silver and litharge of various qualities. As a secondary operation of the metallurgical treatment, we shall hereafter speak of the revivification of certain varieties of litharge.

Coal.—The coal used at Vialas comes from the basin of Portes. Usually dirty, and mixed with schistose dust, it yields dirt or hammer slag. In 1851-52 it cost 2f. 15 the metrical quintal.

Coke.—The coke comes from Besseges. The proportion of ashes varies from 10 to 15, and often 18 per cent. In 1851, the washed coke (about 10 per cent. being ashes,) cost 5f. 15 the quintal, and the common coke 4f. 95. The freight from Besseges

to Vialas was 3f. 25 per 100 kilogrammes—at this day freight is lower.

Charcoal.—This is used only for starting the fires in the furnaces, and for the revivification of the litharge. It costs at the furnace 6f. per quintal.

Fluxes.—The slags of the forge used, accidentally come from the forges of Tamaris (Alais), whence the foundry of Vialas supplies itself with iron, castings, &c.; these small quantities cost nothing, but in case of constant usage, this stuff could be obtained for 18f. to 20f. delivered at the smelting works.

Limestone.—This stone is too rare around Vialas to be used as a flux constantly. Limestone is introduced in the layers for fusion; r eality, they insert for the sole of the cupel, a kind of silicious and micaceous *marne* (clay), which comes from the region of Pont-de-Montvert. It costs at Vialas 25f. to 30f. per cubic metre.

Fluor Spar.—We know on the north of the Loziere some veins of pyritous-galena with a gangue rich in fluor spar, but they are too small and distant from Vialas.

Materials for Construction.—For the exterior wall of the melting and reverberatory furnaces, they use mica schist, obtained near at hand. It costs only the quarrying and transportation; for the corners of the walls, coal sandstone of the neighborhood of Portes is used, but the cost of transportation limits its use.

The interior wall of the roasting furnace is made of refractory brick, costing at Alais 6f. per 100 kilogrammes, to which should be added 2f. for transportation. The mica schist of the country lines the interior. Red brick from Alais have been tried, but the results were not satisfactory. So far as relates to the mica schist, it is but an ordinary material for this purpose.

The earths for lining, of close beaten charcoal (*brasques*), are powdered schists, forming a very fatty clay, which is obtained around *Genohloe.* It costs from 0f. 70 to 0f. 80 per 100 kilogrammes delivered. The sand is taken from the river, and costs to transport it 0f. 05 per 100 kilogrammes. The limestone costs, delivered at the furnace, 2f. 15 per quintal.

The iron for tools, &c., cost, in 1851–52, 30f. to 35f. per quintal delivered. The roasting furnaces are reverberatories, with a single sole, where they pass successively all the periods of a single operation. The sole, apparently rectangular, with rounded corners, is 3^{m} 70 in length, and 1^{m} 80 in breath. The longitudinal section of the furnace gives for the profile of the arch a flattened curve, which is rapidly inflected at the bridge towards the flue. The height of this arch at the sole is 0^{m} 33 to 0^{m} 40 around the flue, and 0^{m} 50 to 0^{m} 60 near the bridge.

The height of the bridge above the sole is 0^{m} 15 to 0^{m} 20 and to 0^{m} 40 above the roasting bars.

The grate is 1^{m} 50 to 0^{m} 60, the flue 0^{m} 30 to 0^{m} 50. Above the gate of the furnace this oven presents five other openings,

one under the flue in the face of the bridge; three others in the anterior longitudinal wall, used for work; a fifth pierces in the arch, and is the guard of an entrance by which the charges are introduced.

The sole is formed of a mixture of one quart of fat earth and three quarts of river sand, which they build by successive layers to a thickness of 0^{m} 15 to 0^{m} 20. They give at the same time a slight inclination towards an orifice placed near the middle working gate or opening, and which communicates with the exterior by a canal traversing the wall of the furnace. It is here that the agglomerated ore issues.

The roasting furnaces have no chambers for condensation; the flues passing through rooms where they collect the fumes before they enter the chimney, are insufficient to retain suitably the matters carried off.

Each roasting furnace is attended by three workmen, who take turns of eight hours each; they perform all the work, the transportation and breakage of the roasted ore. Each of these men receives 1f. 75 per period of eight hours.

The coal of Portes and the ore are the only raw materials of the roasting.

The object of roasting being completely to desulphurize the ore, it is important not to leave any pretext to the workmen for composing the charges in such a manner as to ascribe any want of success to an excess of pyrites. The superabundance of sulphur is not, indeed, the only evil to be avoided; for the first effect of roasting, under the most favorable circumstances, is to give a mixture of various products and a sulphate of lead. It is, therefore, necessary to select the material for roasting, and to avoid a deficiency of quartz as well as an excess of pyrites. We admit that the schlichs, *sands*, *muddy ore* and the products of the cribble are particularly quartzose, whilst the schlichs, *pyrites* and *bourbes* are especially rich in sulphurets of iron. We have already said that this classification is uncertain, and cannot serve as a constant rule; the proof of this will presently appear. The charge is usually composed of 700 kilogrammes of different varieties of products. We will state hereafter the composition of the roasting during a year.

The labor of roasting is divided into six periods: 1st, the making of the sole; 2d, coating of the furnace; 3d, charging; 4th, heating the mass; 5th, (rablage) raking, continued at a low temperature at first, and increasing gradually afterwards; 6th, softening and agglomeration of the mass.

This succession of operations corresponds to the principle upon which the work is based, as has been stated above; the following are the details of the manipulations during the different p riods:

At the close of an operation the furnace is raised to a high

temperature, during which they fear to charge the coarse materials. They leave it to cool, but take advantage of the warmth to repair the sole, which is impregnated, little by little, with considerable sulphurets and oxi-sulphurets, and considerably softened during the last hour of the work. They smooth the sole whilst the furnace is still warm; afterwards they allow the temperature to sink until it becomes a dull red, by opening all the doors for an hour and a half or two hours. Then they introduce a new charge by the entrance of the arch; they extend it uniformly on the sole where it is 0^m 12 to 0^m 15 in thickness. This operation occupies a quarter of an hour, and is done by the workman of two periods, one who goes away and the other who comes.

The workman maintains the fire for an hour, and the material gradually growing warm, assumes a temperature of (glowing) red. Afterwards the blue flames, owing to the combustion of sulphur, begin to appear, and then commences the raking. He rakes during a quarter of an hour and rests five minutes, afterwards he recommences and introduces his tool by each of the working doors; he continues to turn the mass with the spadille in such a way as to prevent agglomeration, by bringing to the surface all portions of the ore, and drawing to or pushing it from the fire surface successively. This work is continued for seven hours, and the temperature is gradually elevated; the air required for the roasting enters by the working doors.

The raking (brassage) becoming more and more difficult, it is still continued for three hours. The workman during this time is often obliged to crush the pasty mass, which is separated or attached to the fire irons. At the eighth hour after the charge another workman comes. He suffers the temperature to increase gradually until the twelfth hour.

At this time the workman gives a blast of heat, which should determine the reaction of the silicious matter upon the sulphate of lead. The furnace is then bright red, and the (brassage) raking is pursued for two hours, in such a manner, that at the fourteenth hour, they open the discharging passage, and the workman aids the flow of the pasty matter, by bringing it constantly towards the orifice of the outlet; it falls upon the sole of the smelting works, where it forms a cake of five to six centimes in thickness.

The workman of the next period now arrives, that is to say, at the fifteenth hour after the preceding operation. They sprinkle with water the cake of roasted ore, and then the workmen break it in fragments of the size of an egg at least, and take it to the heap at three or four metres from the furnace. During this time the furnace cools for the next charge.

The average length of working a charge of 700 kilogrammes is thus 16 or 17 hours.

The products of roasting are:—

The roasted ore; the fumes of roasting; the fonds of the sole:

Roasted Ore.—This product is a whitish gray, in a compact mass, of an homogeneous appearance, and without vitreous brilliancy; but these are the external marks of a good roast, for when the operation has been a failure, the mass becomes bluish, and contains more or less of metallic sulphurets, of which we see the crystalline faces shining here and there. Many varieties, obtained by roastings, supposed to be perfect, have been submitted to analysis; we have observed that the external examination is altogether insufficient to judge of the nature of the roasted ore and of the success of the roasting. On the one hand, it is rare even in the samples where the eye cannot discern a trace that some sulphate of lead is not disseminated; on the other hand, the sulphate of lead is found in notable proportion, and also the sulphate of barytes. These facts are inferred by the following composition, which we offer as the most common of the roasted ore of Vialas:—

Soluble sulphates	traces.
Oxide of lead	46.00
Oxide of zinc	1.50
Oxide of antimony	0.50
Peroxide of iron	6.00
Sulphate of lead	24.70
Sulphate of barytes	7.00
Sulphuret of lead	1.50
Sulphuret of zinc	traces.
Silica (gelatinous)	6.00
Oxide of lead	4.50
Oxide of iron, barytes	0.50
Quartz and clay	1.80
Total	100.00

Proportion in metallic lead 63 per cent.

The desulphurization of the ore is then incomplete, and the point of agglomeration is imperfectly attained. Now, as the analysis shows, the only cause of this fact is the deficiency of silicious matter in the composition of the roastings. There is not in reality but seven to eight per cent. of silica, of which the greater part passes into silicate of lead, thus performing the part which the theory of operations ascribes to it. It is further certain that it would be advantageous to leave in the products for roasting a greater proportion of quartz, that is to say, not to push so far the enrichment of the schlich; all else is in a suitable proportion in regard to the fusibility of the ore.

We insist on these considerations at the outset, because the results of roastings at Vialas seem to be very regular, as we have shown them, and also because an understanding of them removes embarrassments which appear in working the charge.

By the dry way, the roasted ore yields 58 to 60 per cent of

silver-lead, of which the proportion in silver is 360 to 380 grammes per quintal.

Fumes of Roasting.—The secondary product of a composition, naturally very variable, is in a great measure lost in consequence of the absence of chambers for condensation. This is the more to be regretted as they are rich in lead and silver—for they render in the dry way 25 to 30 per cent. of silver-lead to 345 or 350 gr. But little of the fumes collected repass to the roasting.

Fonds de Sole.—Composed of sub-sulphurets and oxi-sulphurets; these are rich in lead, and especially rich in silver. They are regularly renewed all the year at the time of repairing the furnaces; sometimes, also, after an operation, when the sole is too much worn out.

The silver-lead obtained in these (fondonts) contains one kilogramme and more of silver to the metrical quintal. The (bourbes) mud, or powdered ore, are roasted apart; the labor is more rapid than for the ore. It cannot be pushed to agglomeration; the roasted stuff contains likewise a large proportion of sulphates; of 35 per cent. of oxide of lead there found there is scarcely two or three per cent. liberated, the rest is combined with the sulphuric acid. We have already observed that this mud ore is rich in iron pyrites; the roasted product contains in reality 12 to 14 per cent. of peroxide of iron. Some centimes of alumina are found combined with sulphuric acid, proceeding most likely from a little schistose gangue, thus sulphurized during the roasting. In short, the sterile portion of the roasted *bourbes* is composed of 25 to 30 per cent. of quartz and some centimes of sulphurets of barytes or clay.

By the dry way, the assay of this product gives 25 per cent. of silver-lead to 365 grammes of silver. Each charge of 700 kilogrammes requires sixteen hours of work; thus they pass about 1,000 kilogrammes in twenty-four hours, or during three periods.

We estimate the annual repairs of the furnaces and the use and repair of tools at 240 to 250 francs per annum for an average product of 5,000 quintals, at 0f. 049 per quintal.

Among the special expenses the transport of the schlich and coal around the roasting furnace should be estimated.

The special expense of roasting per quintal the raw ore is:

	Fr.
Coal 0q. 465 a 2f. 15	0.999
Labor, 0f. 30	0.525
" and use of furnaces and tools . . .	0.049
Total	1.573

Two smelting furnaces are sufficient to melt the roasted ore, both constructed on the same model; a vat with sides sensibly vertical; two walls, one within and the other without, the sole

inclined; a forward reservoir, and a reservoir for tapping; a single tuyere; an arch resting on the two lateral sides of the exterior wall, above the throat, conducts the smoke of both furnaces into a common chimney, widened at the foot under the form of a chamber of condensation, but altogether insufficient.

The principal dimensions of this apparatus are:—

	Met.
Height of the throat above the working table .	1.70
Breadth at the level of the throat	0.50
" at the tuyere	0.45
Length in the tuyeres	1.00
Diameter at the base	0.035
Height of the throat above the tuyere . . 1.30 and	1.33
Thickness of interior wall	0.50
" of the breast	.0.12

The interior consists of mica schist of the neighborhood, the breast is of brick, usually terminated towards the front by a small surfaced arch of 0^m 10 to 0^m 12 rise; here the products flow out.

The clay used for making the lining is very fat; it cracks in the fire, which makes it necessary to mix with it a high proportion of powdered coke—usually six to eight parts of coke to one of clay are used.

A blast machine serves the two smelting furnaces, the furnace for cupellation, and two small forges for repairing the tools; it can be worked by water power, but most frequently a ten or twelve horse-power engine is used.

The materials first fused are as follows:—

(To be continued.)

Art. VI.—EXPERIENCE OF THE GOLD MINES OF CALIFORNIA.

The fourth Report by Prof. Trask to the Legislature of California has been in our hands a short time. It embraces the explorations of last year, and comprises a portion of the Coast Mountains north of the Bay of San Francisco. There is in addition in these pages an historical sketch and statistical statement of the operation of a number of the gold mines in the State, for different periods of time.

This information comes from such a reliable source, and contains so much valuable experience, that we regard it as the most important feature of the report for our readers. Under this view we present so much as will furnish a very impartial view of the gold mines of California.

MAMMOTH MINE SEVENTY-SIX, JAMISON CREEK.

This mine is situated on Jamison Creek, in the County of Plumas. It was located and opened in 1851. The lode is heavy, and belongs to the primitive ranges, situated near the eastern line of the State, and near the main ridge of the Sierra Nevada.

It is beyond doubt but a continuation of that line of lodes on which the Ariel Mine is located in the County of Sierra, eighteen miles southward of Downieville, on the south branch of the North Yuba, and also that of the National Mine, on the ridge of South Fork of the Yuba, in the County of Nevada, the Copper Hill and German Bar Mines lying intermediate, and between the Middle Yuba and Downieville.

In 1852 the company commenced work with a set of arastras, and have continued with the same until the present year. During 1855 they have erected a Chili Mill at an expense of $18,000, employing water as a motive, with a capacity equal to thirty horse power. The expense of opening the mine, with the improvements prior to 1855, amounts in the aggregate to a little less than $10,000, making the cash capital invested equal to $28,000 at the present time.

The present condition of the mine is as follows: A main shaft has been driven near the centre of the lode, to the depth of seventy feet, and ten feet in diameter, occupying the power of the lode only; an adit two hundred and sixty feet in length cutting the vein thirty feet below the bottom of the main shaft (the adit is five feet by six feet), which will deliver the ores from the mine with greater facility and quantity, than by the course heretofore pursued, and with a great saving of expense.

An adit is to be connected with the reduction works by a train road. The adit has been driven through the trap rock for a distance exceeding one hundred and forty feet, at an expense of thirty dollars per foot.

On these large lodes, wherever they have been opened, we find the same general rules holding good that have been repeated previously, viz. that a very general increase in power is manifest the greater the depth attained.

In this mine the increase is eighteen inches in twelve fathoms, the vein at this depth being twelve feet in power.

The Chili Mill reduces two and one half tons per diem, the ore yielding thus far an average of forty dollars per ton.

It will be seen from the above statement that this mine, as imperfectly worked as it appears to have been by the slow process of the arastra, together with the absolute amount of ore reduced, which amounts to seven hundred tons only, has paid the entire outlay of capital in its opening, and to the present time the yield being $28,000 with the contingent and incidental expenses.

RECAPITULATION.

Mine opened, 1851; erection of new reduction works, 1855; expense incurred for same, $18,000.

Tons of ore reduced per day, two and a half; average value of same, forty dollars.

Depth of main shaft, seventy feet; length of adit, two hundred and sixty feet.

Cost of adit, $5,320; cost of shaft, $1,260.

Strike of lode, N. 30 deg. E.; dip 40 deg. W.; power, twelve feet.

Walls of lode, talcose schist; ores, pyriferous and gossan.

McGHEE, Director.

EXPERIMENTAL MINE, COLUMBIA, TUOLUMNE COUNTY.

This mine is situated about one and a half miles north of the town of Columbia, in the County of Tuolumne.

It was first located in 1852, and some little money and labor expended upon it, sufficient to fairly test the character of the vein.

From this time until the early part of 1854, little or no labor was bestowed in developing the mine. During that year a company was organized with a small capital, who proceeded to erect a mill and reduction works, driven by water, and continued in operation until the failure of a sufficient supply of the motive power compelled them to suspend their operations for the time being.

The capital invested in erecting their reduction works amounted to $3,602; and at the end of a little more than four months the mine yielded $16,150 from fifteen hundred tons of ore, giving an average of a little more than ten dollars per ton.

This, however, is but a preliminary movement to a larger operation, as the aggregate yield was found to pay a large interest on the capital invested.

SPRING HILL MINE, AMADOR, AMADOR COUNTY.

Cash capital $18,000.

The Spring Hill Mine is situated on Amador Creek, about three-fourths of a mile from the town, to the westward.

The lode comprising this mine was located in 1851, by Rice & Co., who commenced operations on the vein in 1852.

It is from this year that the mine must take the date of its existence, for during that period the first mining improvements were instituted.

From 1852 to the beginning of 1855, the lode was worked with variable success by the original owners. This was attributable to the loose manner in which the mechanical and engineering departments were conducted, and the lack of application of those means that were available and most effective during that period. Mechanical skill and a sad want of knowledge of the requirements of mining engineering marked its progress for three

years, at the end of which time the mine was in a condition little better than valueless, and the motive power nearly on a par with the subterranean workings. The whole appearance of the property was that of a "*present*" interest only, and each department of its conduction was but a reflection of the same image, too frequent still, even at this time.

The result of the above operation was the disposition of the property at a mere song, a moiety of its true value, which took place in the latter part of 1854.

At this period a new company came in possession of the entire property by purchase, and commenced the first improvements that partook of the character of permanency in the slightest degree. Their first movement was to place the mine in something like a safe working condition, which required a heavy outlay of capital in addition to the purchase, they being obliged to repair the defects of the workings of previous years. This done, they then commenced the extraction of such ores only as could be removed without subsequent injury resulting to the mine, and secured their excavations, as they proceeded, in a permanent manner. In the course of these workings, from their directions and the relative position of the older excavations, it became necessary to cut the latter, in order that easy and efficient communication might be had with the reduction works, for the transportation of the material of the lode; and in pursuing this course it was not unfrequently that the old works, as they approached them, would give way, from the total insufficiency of the artificial supports that were placed in them.

Thus, after encountering obstacles of the above character, the company have succeeded in not only placing the mine in a safe and accessible condition, but have also taken from the lode an amount of ore sufficient to meet their outlay in repairs and other improvements, and a handsome profit on the capital invested.

Since its occupancy by the present company a new building has been erected over the mill and wheel, and another for the accommodation of their men employed, which is twenty-six by fifty-two feet, at an aggregate expense of $3,500. The dead work consists in driving their upper adit one hundred and fifty feet, at an expense of six dollars per foot, and the sinking of the eleven-fathom shaft at its termination, at an expense of five dollars per foot, which in their aggregates amount to $1,230 more.

The improvements on the mine for 1856, and which are in course of construction by contract, are one adit of ninety feet, at seven dollars per foot. This adit begins at the north shaft of the old workings and runs diagonally into the hill, and when on the vein will afford a line of level about five hundred feet in length. A new sixty-horse-power engine is in process of erection to replace the dilapidated machinery now in use, and a heavy Chili mill in connection with the former, the whole of which will be driven by a sixty-horse-power.

Statistics for 1855.

Number of men employed, 11.

Five miners at $60 per month	$300
One Stoker	50
One Whim-tender	50
Two Battery-tenders at $60 per month	120
Two Engineers at $65 per month	130
One hundred and forty-four cords of Fuel at $5 per cord	720
Provisions	240
Incidentals	240
	$1,850

Average amount of ore reduced per month, 246 tons; aggregate for nine months, 2,221 tons; average value per ton $21; aggregate receipts, $46,000.

Aggregate deads and improvements	$4,730
Average monthly expenses	1,850
Aggregate of expenses	16,650
Total expenses	$23,230
Net balance over all expenses	$22,770

CONDITION OF THE MINE.

	Fathoms.
One Whim Shaft	19
One Air Shaft	19
One Air Shaft	11
Total Shafting	49
	Feet
Lower Level at bottom of Whim Shaft	130
One Adit	274
One Adit	30
Total Levels and Adits	434

Strike, north and south; dip, 68° east; power, nine feet. Ores, pyritous.

PACIFIC MINE, PLACERVILLE, EL DORADO COUNTY.

The ground occupied by the mine of this company was located in 1852, and like many others of that period, had an existence only in the highly elated hopes of those who found the lode. Until 1854 the ground remained unimproved, when the present stockholders, becoming convinced of the value of the lode, commenced operations by opening the vein through shafts and adits, and subsequently by the erection of reduction works during the summer of the year.

The mine was continued in active operation from that time up to the present without intermission, during the period in which water was obtainable, which is their motive power. The absolute running time for the year (ending November, 1855) was nine months and twenty days.

The cash capital invested in the beginning of operations in 1854, was $11,000, about $7,000 of which was expended in the erection of their mill, and the balance in opening the lode and the construction of conveniences to convey their ores to the reduction works.

The amount of work done upon the lode within the year, will perhaps convey a better idea of the activity with which the work has been prosecuted than any other means that could be adopted.

The lode has been opened and is in good workable condition for more than two hundred feet, and at an average depth of nearly sixteen fathoms for the above length below the surface. Near the centre of the lode one thirteen-fathom shaft has been sunk, and is used at the present for bringing the ores from the upper galleries to the surface.

From the west side of the hill an adit has been driven to intersect the lode on a line with the main shaft, and which cuts the lode at twenty fathoms from the surface.

From the entrance of the adit to the reduction works a train road has been carried on the side of the hill, about five hundred feet in length, which is now used for the delivery of all the ores of the mine; this has been constructed during the past year at an outlay of $4,500.

During the month of December the company were engaged in erecting more effective machinery for the purpose of amalgamation, at an expense of about $3,500. This is a judicious movement, as it is most evident that a serious loss of metal has been sustained during the past year's operations.

At the end of the year, terminating the 29th September, 1855, the company had declared six dividends, above all current and incidental expenses, and above original capital investment during the following months. The dividends are on forty-five shares:

	Per share.	Net receipts.
March 31st	$25 00	$1,125 00
May 26	60 00	2,700 00
June 30th	100 00	4,500 00
July 28th	20 00	900 00
August 25th	40 00	1,800 00
Sept. 29th	25 00	1,125 00

The following is the statement of operations at this mine for the past year and its present condition.

RECAPITULATION.

	Tons.
Amount of ore reduced per month	164
Aggregate for nine months	1,524

Average value per ton	$25 00
Aggregate yield for 1,524 tons	39,778 61
Current monthly expenses	1,650 00
Aggregate of monthly expenses	14,850 00
Net profits	24,928 61

	Fathoms.
Length of lower level	34
Upper gallery, north	8
" " south	16
Main shaft	16
Main adit	31

Strike, north and south; dip, 58° east; power, 9 feet; dead work, $4,500.

CHARACTERISTICS OF THE LODE.

The lode is situated in talcose slate, the superior portions of both being much decomposed and easily removed. A large amount of the upper portions of the vein contains cavities holding free gold. At the depth of about forty feet the vein becomes more compact and pyritous, having a slight ribbond appearance, from a small quantity of gruphite being distributed through the seams. The rock is thoroughly impregnated with thin, glistening scales of greenish and whitish talc, the latter often covering the surfaces of fractures entirely, and the latter containing microscopic particles of gold in considerable quantities; at times the surfaces are well filled with fine spangles of gold visible to the naked eye.

This lode contains lead and molybdenum in small quantities, in the form of sulphurets, at times distinct but most commonly combined in the same mineral. Among the ferruginous sulphurets a small quantity of arsenic is noticeable, but to no considerable extent.

This mine is situated in the corporate limits of the City of Placerville, and immediately south of the centre of the corporation.

EUREKA MINES, SUTTER, AMADOR COUNTY.

Cash capital invested, $32,000. The location of this mine was made in the early part of 1852, since which time it has been actively worked up to the present date. Among the early adventures in gold mining proper, the persons who compose this company were among the first who entered the field of research to develop and demonstrate the feasibility and practicability of this branch of industry in this State.

Their first operations were contemporaneous with the few who launched on this tide of speculation in the County of Nevada, and with others in the Counties of Amador (Calaveras) and Mariposa.

The difficulties encountered by these parties at the outset were such as to dishearten most of mankind, but a cool determination and prudence in the management of their affairs has enabled them ultimately to overcome the multitudinous obstacles that opposed their way, and ride out safely the wild tornado of public opinion that made its inception against them during the latter part of 1852 and the beginning of 1853.

From the early part of the latter year the company progressed steadily in their operations, and in the latter part of that year the following was the condition of their mine:

Near the centre of the lode which forms their property, they had sunk one shaft to the depth of seven fathoms; at the bottom of this shaft a level was carried south one hundred and forty-three feet, and north ninety-five feet, making two hundred and thirty-eight feet of levels at the close of that year.

During this year a heavy and long adit was commenced on the east side of the hill, which was driven through solid rock three hundred and seventy feet, and at an expense of eighteen dollars per foot.

During the year 1854 the main shaft was carried to the depth of sixteen fathoms, and an adit of one hundred feet driven on the west side of the hill, which intersects the main shaft at the depth of seven fathoms, and the upper galleries at the same point. The upper galleries were driven one hundred and fourteen feet further south and seventy-five feet north.

At the bottom of the sixteen-fathom shaft levels were driven north sixty feet and south eighty-five feet, making one hundred and forty-five feet of levels, fifty-four feet shafts and one hundred feet adits, on the lode and west side of the hill during that year; the train-track and adit on the east of the vein having been completed to the length of nine hundred feet during the same period.

At the close of the year ending December 1, 1855, the main shaft had been sunk four fathoms, and a level driven south ninety-four feet and another north to the depth of thirty feet, and the long adit driven to the depth of five hundred and thirty-five feet below the surface; at this depth the vein carries a power of twelve feet.

Prior to 1855 a portion of the lode only had been taken out, from the meagre character it presented—seven or eight feet being the maximum of the strength of the lode used for mill-work. But since the commencement of 1855 that position of the vein formerly rejected has, at the depth of one hundred and thirty-two feet, assumed sufficient value to warrant its extraction, and the result is, an increase of one-third more ore in the same depth opened.

The ores now taken from the mine are one hundred and twelve feet below the water line.

During the months of January and February the Directors declared three dividends of one hundred dollars per share. The mine is free from debt.

The limited capacity of the reduction works, and the increase in the power of the lode, bear little relation to each other; and the company, in place of stopping their present battery to erect one of greater power, purchased during the past year an adjoin-

ing mill, with its water privileges, of nearly equal capacity to their own, at an outlay of $6,000, and with an additional expense of $1,500, have put the same in operation, thereby doubling their former capacity for reduction. Expenses in repairs on the reduction works for 1855, $1,200.

The scarcity of water in the creek from whence their power is derived, during the past year, has been such that but six months' full running has been made, during which the average amount of ore reduced was fifty tons per week. During the dry season the average of reduction amounted to twenty tons for the same period of time.

The following statement will give the comparative expense in conducting the operations of this mine for 1854 and 1855.

STATISTICS FOR 1854.

Cash capital, $32,000.

4 Miners	$400	
2 Stokers	120	
2 Battery Tenders	150	
1 Carpenter	100	
1 Blacksmith	100	
1 Horse Team	216	
1 Ox Team	192	
Provisions, etc	900	
Incidentals	80	
	$2,258	
Dead work on shaft and equipments, 54 feet, at $20 per foot		$1,080
Adit and train, 370 feet, at $18 per foot		4,660
West Adit, 100 feet, at $8		800
Aggregate monthly expenses for nine months		20,322
Aggregate receipts per month, for nine months, at $4,000 per month		$36,000
Expenses		26,862
Balance		$9,138

STATISTICS FOR 1855.

4 Miners	$280	
2 Stokers	120	
2 Battery Tenders	150	
1 Carpenter	75	
1 Blacksmith	75	
1 Horse Team	216	
1 Ox Team	192	
Provisions, etc	600	
Incidentals	60	
	$1,768	
Dead work on adit, 165 feet, at $7 per foot		$1,155
Expenditures on Mine and Mill		13,298
Total ore reduced for 6 months, 1,296 tons; do. do, for 6 months, 396 tons		
Aggregate Expenses		14,496
Total receipts		33,000
Total expenses		28,949
Balance		$4,051
Balance to credit on purchase of New Mill		6,00

The greater proportion of the latter has been expended in improvements and liquidating liabilities.

The balance for 1855 is over and above all expenses and dividends for the year, a very material decrease in the expenses of conducting the operations of the mine from that of 1854, which is a general rule throughout the State.

The following recapitulation will show the condition of the subterranean works on the lode:

RECAPITULATION.

	Fathoms.
Depth of Main Shaft	22
	Feet.
Length Upper Level	230
" Middle "	145
" Lower "	124
Total length of Levels	499
	Feet.
West Adit	100
East "	535
Train Track	430
Total length of Adit Tracks	1,065

Power of Lode, 12 feet; dip of Lode, 70° east. Strike, north and south. Aggregate amount o f ore reduced, 1855, 1,692 tons. Average value, 20,

KEYSTONE MINE, AMADOR, AMADOR COUNTY.

This mine, like that of the Eureka, was one of the pioneer operations of the State. The mine and reduction works are situated but a short distance west of the town of Amador, on a small tributary of Amador Creek.

The first permanent workings of this mine were commmenced in the early part of 1853, and though superficial in their character, were prosecuted with vigor for a considerable part of that year. At the close of 1853, and in the early part of the following year, the old workings were abandoned, from the insecurity of the artificial supports used during the preceding period.

It was at this time that the necessity of more permanent supports for the excavations became apparent to the conductors of the mine, and during that year they commenced their permanent structures in the underground operations; their first movement being the cutting of a main shaft of sufficient capacity to afford easy ingress and egress from the main adit to the lode below its level. During 1854 this shaft was driven to the depth of eight fathoms on the vein, and conforming to its dip, and from the top to the bottom was timbered heavily with oak, and the angles snugly tenoned and jointed, the ceiling being put in with heavy planking, and closely squared. By this tedious and expensive process the mine was safely secured from falling in, the upper part of it at least, a result which must have ensued had the old

system of working been persisted in. The old works above the main adit were still in a weak condition, and began to present many features of falling in, and which would have produced serious inconvenience had they neglected to secure it in a proper manner.

An inclined shaft was accordingly commenced that would connect that sunk from the end of the adit with the surface, in a direct line of inclination. This was done during 1855, and the depth of that portion of the shaft above the adit was seven fathoms.

This whim-shaft was cased with solid timber from top to bottom, and put in with close joints, as it became necessary to use this heavy material in place of planking, from the loose character of the surrounding ground. The ores are now raised by a horse-whim, through the line of shafting as described, and landed at the end of the main adit, from whence they are conveyed on train-ways to the reduction works, about four hundred feet north of the entrance to the mine.

During 1855 the sinking on the lode in a line with the whim-shaft has been five fathoms, and from this depth the lower level has been driven one hundred feet north, and south about twenty feet. The upper gallery has been driven each way but twenty-five feet.

The lode at the depth of twenty-one fathoms, has a power of nine feet for one hundred feet in length. The ores of this mine are highly pyritous, and strongly impregnated with graphite, the latter mineral imparting at all times a black, mottled appearance to the ores, and at others a ribbon-like form, giving the idea of true lumination.

At the depth of seventeen fathoms the ores lose the character of porosity which in the superficial ores was a striking characteristic, the cavities containing free gold. The walls of the lode are of a graphic slate, often impregnated with arsenical crystals of iron, and the simple sulphuret of that metal.

During 1854 this company declared monthly dividends through the year of $200 per share. The following statement will show the condition of the mine and the relative expenses of working for 1854 and 1855:

STATISTICS FOR 1854.

Number of men employed, eighteen.

Six Miners, per month	$390
Two Engineers	180
Two Stokers	120
Two Battery Tenders	120
One Teamster	70
One Blacksmith	70
One Carpenter	70
Provisions	416
Incidentals	288
Eighty-five cords Wood per month	425
	$2,149

Supplies, Repairs, etc.	$185
Dead Work and Improvements	6,181
	$6,366

Average ore reduced per month, 192 tons—2,204.

Average value per ton, $21	$46,284
Aggregate monthly expenses	25,780
" deads and improvements	6,368
Total receipts	46,284
Total expenses	32,148
Balance	$14,136

STATISTICS FOR 1855.

Number of men employed, twenty.

Eight Miners	$420
Two Engineers	150
Four Stokers	200
Two Battery Tenders	120
One Teamster	65
One Blacksmith	65
One Carpenter	65
One Whim Tender	70
Incidentals	200
Seventy-five cords of Wood, at $4 50	336
Provisions	400
	$2,091
Dead work and repairs	$1,200

Ore reduced, 3,000 tons.

Average value, $20 per ton	$60,000
Aggregate monthly expenses	26,282
" deads and improvements	1,200
Total receipts	$60,000
Total expense	27,482
Balance	$32,518

During the month of March a dividend of five hundred and fifty dollars per share was declared, since which period two others have been declared, the amount of which is not ascertained.

The following recapitulation will show the amount of work performed upon the mine:

RECAPITULATION.

	Fathoms.
North Shaft	4
Main "	21
Total	25
	Feet.
Upper Gallery	190
Middle "	200
Total	390

One adit of 140 feet

Strike, north and south; dip, east. Power, nine feet.

(To be continued.)

COMMERCIAL ASPECT OF THE MINING INTEREST.

MINING STOCKS IN BOSTON.

Boston, November 29, 1856.

The Mining Share Market has presented few features of interest the past month, and the fluctuations in prices were not so large as at some former periods. The amount of stock on the market is exceedingly limited; and in some few cases orders cannot be filled from lack of sellers. The increased demand for money has, doubtless, acted adversely on this class of stocks, and prevented investments which would otherwise have been made.

Minnesota sold up as high as 104, at private sale, about the first of the month; but this advance was partially caused by certain parties, who had sold "short" at 85 and less, becoming "cornered," and therefore obliged to take in stock to meet their maturing contracts at best price. Shortly after quotations receded to 96, on forced sales, and since rallied to 98, at which the stock is now dull; but very few shares are offered for sale.

Pittsburg fluctuates between 227 and 229, which is about $3 lower than a month since; though transactions are very light, and probably not more than 50 shares could be obtained at or under 230. Both this and the Minnesota Company are doing a first-rate business, and the stocks are as sure dividend-paying securities as any in the market. The only point is, as to the *amount* of their respective forthcoming payments.

Rockland has been up to 85, for a small lot, but since declined to 82, at which all the lots offered were taken. This stock is about $5 per share higher than the Minnesota was after having paid two annual dividends. But the argument is that the Minnesota sold too low, and not that the Rockland is too high. The stock is held mostly for investment, and many believe that the mine will eventually equal the Minnesota in value. But for this *future* expectation the stock would certainly be classed as high, far beyond its intrinsic value.

National is looked upon with favor, and the stock is scarce, and cannot be obtained at $25, which is an improvement. This mine is making a good show, and promises to take its place among dividend-paying concerns within reasonable time—not farther off than two years probably.

North American is wanted at 20; but no stock can be had at that price, or even 25 probably. The stock does not come into the market much here, a limited number only of the shares being held in this vicinity. We believe the mine is doing well, and its future prospects are thought to be flattering.

Isle Royale farther declined since last month, and finally touched 4¼, under adverse reports, manufactured and otherwise. The price rallied, however, and the shares now sell at about 5⅝. The mine never looked better than at the present time, and the yield for October was 20 tons, a better result than for any month since May last. The large falling off in the product, from the estimate of 800 tons, to the actual result of only about 230, has, of course, shaken confidence very much as to its present value; but yet there can be little if any doubt that the shares are really worth double the price of to-day. Even at 230 tons, the product stands *third* among the Lake Superior Companies, only the great mines of the Minnesota and Pittsburg yielding a larger amount for 1856.

Superior has sold at $10, but is dull at that now, and the price looks very high for a new mine, in which very little labor has yet been expended, and no copper raised of any account. The "Minnesota vein" runs through the property, however, and it is this, more than any actual results, which gives the stock an enlarged market value at present. As only $1 per share has been assessed, and this was to raise money ($20,000) to pay for valuable territory purchased, we presume farther calls must be made for means to develope the mine.

Pewabic fluctuates between 4½ and 5, and is rather a favorite with buyers. The product for 1856 will exceed 100 tons, the largest *first year's work* of any mine at the Lake; and it has been so economically managed, that this will yield a clear profit of some $12,000. Possibly this will place the concern beyond farther assessments, though this is not a certainty, but a result hoped for. The amount paid in is $1.75 per share on 20,000 shares.

Quincy is wanted at 7 bid, and 9 asked. This Company has only 8,000 shares, and is doing well. Owing to some discrepancy in the past issue of certificates the stock has been suspended at our Board here for about two months, but introduced again recently, and will probably be dealt in to considerable extent. The whole value of the mine at the present selling price (say $9), is but $72,000, while the Superior, at $10 per share, would be $200,000.

Flint Steel is dull and not wanted at 4, without sales for many weeks. This is also an "off-shoot" of the Minnesota, but does not, as yet, seem to have found the famous vein of that successful concern.

Central is also dull at about $5, and no transactions have been made publicly for some time past.

Norwich sells occasionally at about $3, but is not much known in this market.

Phœnix would bring 1½ to 2, but is very seldom sold, being mostly in the hands of parties who are bound to "hold on," and wait quietly for future results.

Star is seldom quoted, and would not sell for more than $2 to $3 per share.

Huron is quoted at about $2, but finds neither buyers nor sellers to any extent.

Nebraska sells at 1½ to 2, and comes into the market but little.

Copper Falls has settled down to $1 per share, from expectation that farther assessments are inevitable.

The above summary includes all the mining stocks known to this market, which would bring $1 per share or upwards.

Correction.—In our last month's article it was stated that *Copper Falls* had receded to "81½" per share, which would have read more correctly with the "8" omitted. Although so much depressed now, the stock once sold at about $65 per share, and since then at least $10 has been assessed.

COALS AND COLLIERIES.

ANTHRACITE COAL TRADE IN 1856.

Shipments by Reading R. R. to Nov. 16th,	1,992,755 01	tons.
" Schuylkill Canal,	1,042,830 07	"
	3,035,585 08	"
Same time last year,	3,153,345 09	"
Decrease so far,	117,769 10	"

Delaware and Hudson Co.'s Coal Trade.

To Nov. 8th,	470,200	tons.
To same time last year,	528,754	"
Decrease so far,	58,554	"

Pennsylvania Coal Co.'s Coal Trade.

To Nov. 8th,	527,699	tons.
To same time last year,	445,240	"
Increase so far,	82,459	"

Scranton Coal Trade for October.

East towards New York,	22,346 16	
West " "	20,848 11	"
Total,	43,195 07	"

LEHIGH COAL TRADE FOR 1856, BY CANAL.

To September 26th.		
Summit Mines,	269,166 02	tons.
Room Run Mines,	59,868 18	"
East Lehigh Mines,	80,196 14	"
A. Lathrop's Pea Coal,	1,815 09	"
Spring Mountain Mines,	89,990 16	"
East Sugar Loaf Mines,	61,786 17	"
Colerain,	67,928 17	"
Stafford,	11,208 06	"
N. Y. Lehigh Coal Co.,	86,844 17	"
German Pennsylvania Coal Co.,	21,069 19	"
South Spring Mountain Ridge,	24,515 05	"
Hazleton Coal Co.,	125,874 06	"
Cranberry Mines,	69,426 04	"
Diamond Mines,	44,065 07	"
Council Ridge,	48,171 18	"
Buck Mountain Co.,	92,021 08	"
Wilkesbarre Coal Co.,	18,876 10	"
Wyoming Coal,	12,789 11	"
Hartford Coal Co.,	9,504 18	"
Total,	1,098,011 11	"

Lehigh Valley Railroad.

To Sept. 26th.		
Wm. Milnes & Co.,	80,289 14	tons.
Ratcliff & Johnson's,	2,850 08	"
Packer, Carter & Co.,	88,519 09	"
N. Y. & Lehigh,	12,096 08	"
Sharpe, Leisenring & Co.,	8,857 09	"
German Penna. Coal Co.,	7,185 15	"
Dobbin & Dehaven,	851 11	
Total,	150,250 09	"
By Canal,	1,098,011 11	"
Total,	1,248,262 00	"
Same time last year, (Canal)	1,205,069 06	"
Increase in 1856, so far,	88,199 14	"
The decrease by Canal is	112,057 15	"

CUMBERLAND COAL TRADE FOR 1856.

To November 15th,	
Cumberland Coal and Iron Co.	184,644.06
Percy & Co.	9,284.08
Ætna Coal Co.	10,185.19
Frostburg Coal Co.	
Borden Mining Co.	
Allegany Mining Co.	151,941.00
Carbon Hill Coal Co.	
Wellersburg Coal Co.	
(From the Westernport region up to Nov. 8th.)	
George's Creek Coal Co.	88,096.08
Swanton Coal Co.	40,322.17
American Coal Co.	48,425.14
Franklin Coal Co.	128,687.10
Lonaconing Coal Co.	25,617.18
Preston Coal Co.	2,626.12
Hampshire Coal Co.	82,564.10
Total,	628,085.07

CUMBERLAND COAL.

The increasing demand for this article of fuel is such, that every avenue to market is likely to be soon crowded to accomplish its transportation. We have been induced to make some inquiries, in quarters likely to afford reliable information respecting its peculiar characteristics as compared with other coals.

The analysis of Cumberland coal exhibits the following constituent elements:

Carbon, 77 to 85 per cent.
Bitumen, 12 to 15 per cent.
Earthy Matter 4½ to 6 per cent.

These proportions vary within the limits above expressed in various specimens, but the general uniformity of result, in many analyses by different chemists at different times and from various localities in the coal region, is remarkable. The best anthracite exhibits under analysis from 80 to 90 per cent. of carbon, from 10 to 16 per cent. earthy matter, and in many specimens a very considerable quantity of sulphur, but no bitumen.

By comparing the above, it will be seen that the small proportion of earthy matter, the absence of sulphur, and the presence of inflammable bitumen, makes the Cumberland a *free burning coal*, readily combustible in the ordinary draft of steam chimneys, chiefly distinguishing it from the anthracites, which latter, from the very nature of their constituent elements, and the absence of bitumen, can never so readily be brought into ignition.

The process of *coking* which bituminous coals undergo in combustion, liberates the highly inflammable gases which are thus more readily brought into contact with the flame in the one case than the other.

The circumstances attending the combustion of the two varieties of coal, illustrate the theory developed by the analysis; the one burning freely with much flame, some smoke, and long endurance, under a natural draft; the other refractory, difficult to ignite, and only giving out a high degree of heat, by the application of a strong artificial blast by means of blowers.

It has taken ten years to demonstrate the superior qualities of Cumberland coal, but wherever introduced it has uniformly asserted its superiority. Experiment shows that the evaporative power of Cumberland coal is 25 per cent. greater than that of Anthracite under a steam boiler; to say nothing of the less amount of injury to which the furnace is subjected, owing to its freedom from sulphur.

The cost of the two coals as now delivered in the Eastern market bears the same relation, and it has been by its superior qualities alone that the Cumberland coal has at last slowly won for it a consumption rapidly approaching a million of tons per annum. A new and wider field is about opening to it in the vast passenger and freight traffic upon our railroads, where it is being introduced to displace the wood hitherto furnished from our luxuriant forests, and which ere long must have entirely disappeared to feed the insatiable demands of the locomotive engine.—*Baltimore American.*

RAILROAD FUEL.

The subject of providing fuel, to supply the motive power of railroads, grows every year more interesting and important. The number of miles of railroad in the United States, at the commencement of the present year, was about twenty-two thousand; and the locomotive engines on these roads must be not less than five thousand. Supposing each to use wood, as a large proportion do, and the amount consumed in a year by each locomotive to average eight hundred cords, and we have between four and five millions of cords of wood annually burned; the product of at least one hundred thousand acres of woodland annually swept off. In the consumption of wood in stationary fires, for whatever purpose, the ashes enter into useful purposes, for manures, and for chemical uses, but the wood burned on railroads is a dead loss, except for the driving of the locomotive.

One effect of this consumption, we perceive already, in the increased price of wood as fuel. Wherever the railroad competition directly affects the market, the price first rises; and in sympathy with the increased price at certain points, all others feel it, more or less. The conveniences of transportation, which railroads have not only directly increased, but indirectly promoted, equalize the prices of all commodities. Wood now, in our cities and in their neighborhood, has risen to a price which compels the consumption of coal. Many farmers burn coal, and send all, except their refuse wood, to market. Mechanical ingenuity has opened the way to make even refuse wood merchantable; and already it is sold in lots in New York at the small groceries, in quantities of pennyworths and upwards. Private individuals and house-

holds are compelled to the use of coal as fuel, by motives of economy, and the poorer the consumer the more absolute is the compulsion. This result is, in no small degree, to be attributed to the increase of railroads.

Having thus forced the use of coal upon private individuals, a result at which we have no reason to complain, it becomes the railroad interest to be looking to its own profit. It is an axiom in political economy, that an increased demand for any article of which there is an unlimited supply lessens the price. The value of coal has diminished, while that of wood has increased. When the value of any commodity rises above the profitable use of the consumer, the trade must be abandoned which absorbs the article, or a substitute must be found for a material which does not yield a living profit. The railroad interest, the great carrying trade of the world, cannot be relinquished. Neither, we apprehend, will the public submit to a rise in the price of conveyance, which will compensate for what must be ultimately the increase in the price of wood.

The obvious alternative is the substitution of coal as fuel. It is attended with no difficulties which mechanical ingenuity cannot overcome. Experiments have demonstrated its practicability; and that ingenuity has not been more turned to the subject, results only from a disinclination on the part of railroad companies to institute new experiments while they can avoid them. The objections to denuding the country of its forest trees, based on general and on agricultural considerations, are weighty; but we do not press them, because it is next to impossible to satisfy any corporation or individual, that it is a duty to sacrifice private present considerations for the public prospective good. Interest is and must be the main lever in all the single operations which make up the aggregate of the national business or benefit.

Add to the present demand for coal the supply of railroad fuel, and the increased market would, by stimulating the mining interest, still farther reduce the price of fuel. New coal fields would soon be opened, and not only Pennsylvania, but all the States in which coal lies would be benefited. Without the use of coal the railroad system of the United States cannot be much farther permanently extended. With the use of coal the railroads will make a good portion of their own business. All over about thirty-five cents in the price of a ton of coal delivered to the consumer is money paid for labor and transportation, except the dealer's profit. But a cord of wood is worth almost nine-tenths of its value before it is cut down, and its bulk is so great that it will not pay, except for water carriage, to any great distance. From the introduction of coal on railroads as fuel, we may date a great increase of their usefulness to the public; first, in the employment of laborers, and increase of the mining business, and next in the reduction of the price of fuel to every body. A diminution in the running cost of railroads is a great desideratum; and there is nothing which promises to do so much towards it as the general substitution of coal as fuel for locomotives, instead of wood.—*Philadelphia American.*

WARD COAL AND IRON COMPANY.

Below we present a portion of the report of Prof. James Hall, of this State, relative to the property of the Ward Coal and Iron Company, which is located in the Cumberland region of Maryland. Coal, clay, iron ores, limestone are abundant on the property:—

GEORGE C. RIPLEY, Esq.,

President of the Ward Coal and Iron Company:

SIR—In accordance with your request I have examined the estate of your Company, at Barrallville, near Cumberland, Maryland, with a view to the determination of the extent and value of its coal, iron ores, fire clay, &c.

The estate embraces two thousand nine hundred and twelve acres, having

an extension north-east and south-west of about four miles, and a width of one mile and a quarter. The village of Barrallville, containing tenements for about forty families, a school-house, store, tavern, barns, stables and out-buildings, is situated near the centre of the estate, and belongs entirely to the company. In addition to this, there is a steam saw-mill, a brick machine, brick works and kilns, cooking ovens, &c. These improvements, together with the coal openings, have communication by a railroad branch with Mount Savage Railroad, thence to Cumberland, Md.

This tract is situated upon both sides of Jennings' Run, and upon the north fork of that stream. It lies upon the easterly margin of the Cumberland Coal Field, extending thence to within two miles of the centre of that basin; and its northern boundary is the Pennsylvania State line. It is nearer to the city of Cumberland and to the Baltimore and Ohio Railroad, as well as to the Chesapeake and Ohio Canal, than any of the tracts within this basin from which coal has been wrought to any extent.

This position, upon the easterly side of the basin, the general direction of which is from north-east to south-west, presents the strata all dipping to the north-west or west-north-west; their out-crop on the line of strike being along the higher parts of the track towards the east. The valley of the north fork of Jennings' Run, however, lies in a manner parallel to the line of strike, and to the west of the centre of the tract; and the denudation along this line has removed the superincumbent strata so that the two lower coal beds are reached at their present openings at about twenty feet above the level of the stream. This allows of working the beds in the direction of their rise along the slope of the hill; the loaded cars move along a descending grade, and the coal is deposited at the mouth of the same into railroad cars, which have communication with the Mount Savage Railroad, and thence at Cumberland with the Baltimore and Ohio Railroad and Chesapeake and Ohio Canal. The valley of this stream has rendered accessible the beds of coal, iron ore, fire clay, &c., along one or both sides of its course, and offers every required facility for concentrating these products at any point along a distance of a mile or more, and particularly towards its junction with the main stream.

The estate, in its relative position to the railroads and to Cumberland, has superior advantages. About two thousand acres of the tract are heavily timbered; the remainder consists of farms, the valley of the stream, in which is situated the village, &c. This valley, along its central portion, gives access to all parts of the tract. It becomes further necessary to consider in detail the condition, quantity and accessibility of the mineral products; and it is proper to state that these examinations of the coal, ores, &c., were made at points previously opened for the purpose of testing the quantity and quality of the material.

On approaching Barrallville by the road from Cumberland, we find that the coarse sandstone and conglomerate, which every where underlies the coal measures, is cut through and exposed at the level of the stream, thence rising to the east and north-east, and in the opposite direction passing beneath all the coal beds. It is above this rock, therefore, that we are to look for any productive coal seam.

A short distance above the out-crop of the conglomerate, the lowest coal seam is exposed on both sides of the north branch of Jennings' Run. It has been penetrated by a shaft on the north-east side, and also opened upon its out-crop and rather extensively worked. This bed is known upon the estate by the name of the Bluebough coal bed. Entering the opening of this mine, I penetrated its main passages to their extremities. The works are in good order, and the mines in a workable condition at this time, although no coal, except that used upon the place, has been mined for some time past. The actual measurements of this bed, in detail, give—

6 to 8 inches coal,
12 to 16 inches shale,
24 to 32 inches coal.

As this is all worked together, it may be regarded as a full three feet bed of coal, exclusive of the shale. There is an increase of thickness as the bed is penetrated, and the lowest measurements are near the entrance of the mine.

The roof is of firm slate, and in good condition throughout the entire workings. The coals of the Cumberland coal basin are so well known for their superior qualities as steam-generating coals, and for domestic and other purposes, that it would seem useless to dilate upon that point. The coal of the Bluebough bed is held in the highest estimation for steam purposes, and is said to be preferred to any other in the region. It burns in an ordinary grate with a bright flame and little smoke, and is very durable. It also produces an excellent coke.

The Parker coal lies about thirty-six feet higher in the series, and has likewise been opened upon the left bank of the stream just mentioned, a short distance above the opening of the lower bed. The measurements made of this coal along the drifts where it has been worked, show a thickness of from two feet to thirty inches, with an increase as we penetrate the hill, and may be regarded as giving two feet and a half of coal. The coal of the Parker bed does not differ essentially in its external appearance, or other characteristics from that of the Bluebough bed. The extent of mining operations heretofore carried on in each, seems to have been nearly the same, and the coal of each bed is mined with equal facility. Both mines are in excellent condition for recommencing the work of mining on a large scale, if it be considered desirable.

At twenty-five or thirty feet above the Parker coal bed is another, known as the Powell coal bed, and said to have a thickness of three and a half feet. This bed was not opened at the time of my examination, and I have therefore no personal knowledge of its character.

In the ascending order, another bed of coal, known as the Percy coal bed, lies some forty or fifty feet above the Parker coal bed, and about twenty feet above the Powell coal bed. This is said to be from twenty-eight inches to two feet and a half thick, and the coal of good quality. At the time of my exmination this bed was not opened so as to permit of personal examination.

Some thirty feet higher lies a fifth bed of coal, known as the Hall bed. This has been opened on Jonsie's Run, and has been worked to some extent, and a quantity of coal now lies at the mouth of the mine, which has withstood the action of the weather for several years, and is still in good condition. A fresh mass of this coal presented a brilliant fracture, and freedom from impurities, which indicate a valuable coal. The absence of iron pyrites may be inferred from the fact, that the coal lying so long exposed, is still firm, and shows no effects due to the decomposition of this mineral. The bed is said to be four feet thick,* but not having been wrought for some time, the condition of the interior of the mine did not admit of our entering.

There is a sixth bed of coal, known as the Rush Run coal, having a thickness of two feet; and still higher, another bed of two feet thick, having immediately above it a bed of iron ore fourteen inches thick; although the coal alone in this bed may not be sufficient to prove profitable working, it may be found practicable hereafter, when the manufacture of iron shall be established, to work both the coal and iron ore at the same time.

Of these several beds of coal, my attention was especially directed to the Bluebough, the Parker and the Hall beds, the former two of which are now in excellent working condition, and the third has been opened to a sufficient extent to prove its thickness and quality.

The openings of the first two, as before said, are directly upon the railroad, and of the other upon Jonsie's Run, where a descending tram-road or railroad may be made for a short distance, to connect with the railroad along the north fork of Jennings' Run.

* I have the authority of Mr. Hall, the foreman manager of the place, under whose direction it was opened, for the thickness of the bed.

Fire Clays.—Beds of fire clay out-crop at numerous points on this estate, and the quality of some of these is second to none in the country for the manufacture of the best of fire bricks. Other beds, of less pure clay, are adapted to making bricks of an inferior quality, and on the out-crop give rise to beds of clay fitted for the manufacture of common building bricks, and for which purpose it is valuable in this part of the country.

The lowest bed of fire clay seen, lies beneath the conglomerate of the coal measures. It has a thickness of five feet, and at many points along its outcrop can be mined at a very moderate expense.

The second bed of fire clay lies directly beneath the lower coal bed, and is fourteen feet thick, It has been penetrated by a shaft cutting the lower coal on the north fork of Jennings' Run, near the village and brick works, and its out-crop has been traced along the hill to the north-east, where at one point it is now being extensively quarried. It is likewise at other points, at one place, more than two miles to the north-east of the first opening, it has been penetrated by a shaft, and shows still the same character as at the other openings; near the last-mentioned point, also, the lower coal has been penetrated by a shaft.

This clay is of most excellent quality for the manufacture of fire bricks. It is the same in quality as the bed from which the celebrated Mount Savage fire bricks are manufactured.* The bed is accessible every where along its eastern out-crop, and can be wrought with trifling expense. It is likewise accessible at the base of the hill, a short distance below the brick works, and can be wrought either in connection with the lower coal or separately. It has all the advantages of a gradual ascent to the east and north-east, the direction in which it would be wrought, giving, at the same time, a descending grade for the transportation of the clay to the level of the works in the valley of the north fork.

The great thickness, superior quality and accessibility of this fire clay, renders it an item of very great importance in the value of the property; and it may be made a source of large revenue to the estate.

A third bed of fire-clay, ten feet thick, lies beneath the Bluebough and Parker coal beds. A fourth bed of fire clay lies above the Parker coal seam. This bed has a thickness of twelve to fifteen feet or more, and contains several layers of iron ore. The clay is variable in quality in different parts; and though fire bricks have been made of it, care will be required in the selection in order to obtain a uniformity of character. However, it is scarcely possible to anticipate a time when this bed will be required; since the fourteen feet bed of the best clay will afford sufficient material for the most extensive manufacture of bricks for many years to come.

Fire clay of good quality appears at several other points on the out-crop of beds; but I cannot speak with certainty in regard to its thickness. So far as regards this material, the estate possesses an inexhaustible supply of the best quality, and admirably suited for mining and converting into fire bricks.

SCHUYLKILL HAVEN AND LEHIGH RIVER RAILROAD.

This is another proposed route by which the coal of Schuylkill County, Pennsylvania, may reach the Eastern markets. The conclusions drawn by Mr. Rea, the engineer, in the annexed report are very strong in favor of the construction of this road. The parties associated for the purpose, have, it appears, opened books of subscription at Schuylkill Haven. In the report of Mr. Rea are presented the facts relative to the region for the proposed route, and also some comparisons are made with other routes.

* The Mount Savage Company, located two miles west of your works have an iron furnace and rolling mills for the manufacture of railroad iron, and are also largely engaged in the manufacture of fire brick. They at present employ eight hundred men. Their fire brick are made by the old hand process, which costs from $15 to $18 per thousand.

The accompanying Report of a preliminary survey of the railroad route embraced in your charter, is respectfully submitted for your consideration; as also a map and profile showing the ground to be occupied and the grades of the road.

Commencing the survey at the crossing of the Mine Hill and Reading railroads, near Schuylkill Haven, and following as nearly as practicable in preliminary survey the ground likely to be occupied by a located line, the distance to the mouth of Lizard Creek, on the Lehigh Valley railroad, is something less than thirty miles.

The first half of this distance, from Schuylkill Haven to the Summit near Kepner's, five miles east of the Little Schuylkill, covers all the ground in any way expensive to construct a railroad upon, and presents two distinct lines for your consideration. The first, or Northern line will have a grade of twenty feet per mile ascending eastward, and can be constructed at a very moderate expense. The second, or Southern line, will admit of a grade not exceeding twelve feet per mile ascending eastward, but will require a somewhat increased expenditure for construction and for land damages. These lines would unite about one mile west of Kepner's Summit. From this summit to the Lehigh, the valley of Lizard Creek is so direct, and of nearly uniform descent, as to admit of almost a straight line at a very small expense. Upon this portion of your road, the average grade descending to the Lehigh will be twenty-four feet per mile.

Location, Northern Line.—It is proposed to commence the location at a point on the Mine Hill Railroad about two miles above the junction with the Reading Railroad, by which one mile of distance will be saved, and a more favorable grade obtained. There ascending with a grade of twenty feet per mile, cross over the Reading Railroad at the end of the first mile:—then following the slope of the hill to the Poor House, pass the summit at Lessig's with a cut of twenty feet:—then keeping along the Southern slope of the slate ridge, which extends from the Schuylkill to the Lehigh, and crossing the branches of Mohannan and Pine creeks with tolerably high embankments, and keeping north of Orwigsburg, reach the summit at Stigerwalt's with a cut of forty feet deep, and then descend along the Southern slope of the hill to the Little Schuylkill with a grade of forty feet per mile; cross the Little Schuylkill at the Dark Hole north of Ringgold with a high bridge, and then ascend with a grade of twenty feet per mile along the southern slope of the slate hill to the fourteenth mile—then crossing the valley of Koenig's creek near Henry Sassaman's, and cutting through the Limestone Ridge near Jacob Goodshall's, keep along the south slope of this ridge to Kepner's Summit, at the seventeenth mile; and passing this summit with a cut of about thirty feet, commence descending with the waters of Lizard Creek, crossing to the north side of Limestone Ridge with the stream some distance east of the summit, and keeping the north slope of this ridge and the valley of Lizard Creek to Pennsville; then passing through the ridge with the stream, and keeping down the valley, join the Lehigh Valley Railroad near the mouth of Lizard Creek, in a total distance of thirty-one miles.

From a careful computation of the amount of work upon this line, I estimate its cost as follows:

Graduation for double track	$340,000
Bridges, Culverts and Drains, ...	100,000
Superstructures—34 miles tracks and sidelings	272,000
Engineering, stations and sundries	88,000
Total	$800,000

The claims for land damages along this line would be small, as it avoids the more highly cultivated and valuable farming land for almost the entire distance.

Southern Line.—The location of this line corresponds with the northern line to Lessig's Summit. The line then diverges to the south, keeping the valley north of Orwigsburg,—cutting through the summit south of Hummel's,

and taking the north slope of Limestone Ridge to Pine creek,—crossing this creek with a tolerably high embankment near Schall's powder mill, then along the south slope of Limestone Ridge to the summit at Moyer's,—then keeping south of McKeansburg and crossing the Little Schuylkill south of Ringgold:—cutting through the summit between Little Schuylkill and Sechler's run, and keeping along the south slope of Limestone Ridge, connects with the Northern line near Kepner's Summit. This line can be constructed with a grade of twelve feet per mile ascending eastward, without any increase of distance, and would avoid the descending eastward grade to the Little Schuylkill.

The cost of construction would somewhat exceed that of the Northern line,—principally for crossing the Little Schuylkill at a less favorable point, and the claims for land damages would be considerably augmented. A more careful instrumental examination of this line, upon the final location of your road, may lead to its adoption in preference to the Northern line at an increased cost. As a grade of twenty-one feet per mile has been adopted upon the New Jersey Central Railroad, which must govern in a considerable degree the working of trains upon your road; and as the Northern line will afford this grade at a very moderate cost, it was not deemed necessary in the preliminary survey to examine more than the governing points of the Southern line, which establish the practicability of a grade not exceeding twelve feet per mile against a coal tonnage, and of grades ascending westward of not exceeding thirty feet per mile. The determination of the grade to be adopted upon your road, will be simply a question of arithmetical calculation. The difference in cost of transportation upon a grade of twelve feet, or twenty feet per mile, according to the data we have assumed in the following portion of this report would be about 2¼ cents per ton for the entire length of your road, in favor of a grade of twelve feet. Estimating money for railroad investments as worth 8 per cent. per annum, it would require a business something over three hundred thousand tons annually for each one hundred thousand dollars expended in reducing the grades from twenty to twelve feet per mile. A grade of twelve feet would have an ultimate annual capacity of about 3,000,000 tons with a double track, and 750,000 tons with a single track; a grade of twenty feet, a capacity of 2,500,000 for a double track, and 600,000 for a single track. Either would be capable of a business equalling your most sanguine anticipations.

The connections of your road with other railroads, will be highly favorable for coal trade. It will connect directly with the Mine Hill railroad whose tonnage is fast approaching two millions annually; and by a branch of two to three miles your road can connect at Mt. Carbon with the other coal-carrying roads of the Schuylkill. These direct connections are of great importance, as they obviate the necessity of using any portion of the avenues controlled by opposing interests. They also command the outlets of by far the largest proportion of the coal shipped from Schuylkill county.

It will connect with Lehigh Valley railroad, at a point about thirty-eight miles above Easton, and your whole business will thus pass over about five-sixths of the entire length of that road. This will afford the most favorable connection for that company for the coal trade of Schuylkill county, and from the large amount of business awaiting an outlet in that direction, your road will be one of the most important tributaries of the Lehigh Valley railroad, and of the New Jersey Central railroad. You can, therefore, expect to be met by these companies by liberal arrangements for transportation, and perhaps by material aid in the construction of the short link promising to add so largely to their business.

Your road will connect the mines of Schuylkill county by railroad directly with the harbor of New York, by the shortest and least expensive link yet to be constructed for that purpose. Such a road is now required by our coal-mining interests, and could not fail of receiving a large coal and miscellaneous tonnage. It will soon become indispensably necessary to enable our miners and shippers to reach the harbor of New York with their coal at all seasons

of the year in competition with the coal of other regions.—The ability to reach this coal-consuming heart at the season when its demands are the greatest, cannot be too highly appreciated. Those whose foresight and energy have preceded us in this, have every prospect of reaping an early and rich reward.

Will the business offered warrant the construction of your Road, with the prospect of remunerating dividends? To establish this, we would merely refer to the extent of the coal trade, and the proportion of it which will be made tributary to your Road.

The coal trade of Schuylkill county has now reached an aggregate of nearly four millions of tons annually, of which at least one-half goes to New York and points eastward and northward. Of this latter, a large proportion would pass over you Road as soon as completed, rendering it a dividend-paying road from its opening.

By a comparison of the areas of the several coal fields drained by the railroads penetrating them, we find the proportion converging to the following points about as follows, viz:

To Schuylkill Haven, an area of	82 square miles
" Mt. Carbon, ...	32 " "
Tributary to your Road, ...	114 " "
To Tamaqua, ...	20 " "
" Mauch Chunk, ...	40 " "
	60 "
Total from Schuylkill and Lehigh, ...	174

of which your Road, by a short lateral to Mt. Carbon, will command one hundred and fourteen square miles, or two-thirds of the entire coal fields artificially drained by the improvements of the Schuylkill and Lehigh, allowing to the latter about twenty square miles of the Wyoming coal fields. And this large proportion of these coal fields converging upon your Road, is now sending and will always continue to send its full proportion of anthracite coal to market. This proportion of one hundred and fourteen square miles of coal field made tributary to your Road, contains probably a greater amount of coal per acre than any other portion of the anthracite coal fields. The upper beds contain the only Red Ash and Gray Ash coals reaching the eastern markets;—the lower beds contain White Ash coal unsurpassed in quality or quantity by any other region. You can therefore have no doubts of a sufficient coal business for the present support of your Road, with every reason to expect your business to increase as rapidly as you shall be prepared to accommodate it.

Besides the coal tonnage, you can reasonably calculate upon a considerable passenger and miscellaneous trade growing up with a direct railroad communication between the Schuylkill coal region and the city of New York, which will add materially to your business, and be an important item of revenue.

The distance to New York, by the Schuylkill Haven and Lehigh River, Lehigh Valley and New Jersey Central Railroads, is as follows:

Mt. Carbon to Mouth of Lizzard Creek, ...	32 Miles.
Mouth of Lizzard Creek to Easton, ...	38 "
Easton to Elizabethport via N. York Harbor, ...	63 "
Elizabethport to New York, ...	12 "
	145
By Phila. & Reading and N. Jersey Railroads, ...	183 "
By Phila. & Reading Railroad and Delaware and Raritan Canal, .	196 "
By Schuylkill Navigation and Delaware and Raritan Canal, .	226 "

Can your road compete with other lines carrying coal, in the cost of transportation? In the last annual report of the Reading Railroad Company, we have the cost of transporting coal on railroads deduced from the experience on that road for the last five years, by J. Dutton Steel, Esq. This is undoubtedly the most complete and reliable analysis of the cost of transporting coal to

be met with, being from the actual cost of carrying over nine millions of tons over ninety-three miles of road, during a period which takes in the extremes of high and low prices of labor and materials. Adopting Mr. Steele's results as the basis of our calculations, and estimating the interest on the capital employed at 8 per cent. per annum, (which is as low as railroad investments are usually obtained,) we find the cost of transporting coal, per ton, from Mt. Carbon, (or the junction of your Road with the Mine Hill Railroad) to New York, by the connection proposed by your Road, as follows:

By Schuylkill Haven and Lehigh River R. R.—32 miles of 20 ft. grade, transporting 50,000 tons per annum, @ 104 cts. per ton per mile,	33,28	
Interest on Capital, Road and machinery $1,000,000 @ 8 per cent. on 500,000 tons, ...	16,00	
Charge for change of Motive Power, ...	10,00	
		59,28
By Lehigh Valley Railroad, 38 miles level, transporting 1,000,000 tons per annum, @ 75-100 cents per ton per mile	28,50	
Interest on capital, 8,000,000, @ 8 per cent. on 1,000,000 tons, annually, ...	24,00	
Charge for change of Motive Power, ...	10,00	
		62,50
By New Jersey Central Railroad.—63 miles of 22 ft. grade, transporting 1,500,000 tons per annum, @ 91-100 cents.	56,70	
Interest on capital—$5,000,000—@ 8 per cent. on 1,500,000 tons,	26,67	
		83,37
12 Miles River Navigation @ 3-10 c.		3,60
		$2,08,75
Present charges by Schyl. Navigation and Delaware and Raritan canal		2,60
Difference in favor of your Road, ...		51,25
Present charges by Phila. & Reading Railroad and Delaware & Raritan canal, ...		$2,75
Charges via your Road, &c.		2,08,75
Difference in favor of your Road, &c., ...		66,25

Neither of the above avenues pays dividends which will admit of a reduction from present charges; whilst the difference above in favor of your Road and its connections, is based upon a dividend of eight per cent. per annum to the Stockholders of your Road, and to the Stockholders of the connecting roads.

The only competitor which your Road can possibly have for the coal trade of the Schuylkill region, is the proposed Auburn and Allentown Railroad: and as the advocates of that line have initiated a comparison of the two lines, it cannot be considered out of place for us, to briefly continue the comparison.—By that road the distance appears to be about three miles less to Allentown (by using the Reading Railroad,) than by your Road. Its construction will cost double the amount of your Road, it will have an additional change of motive power, and the inconvenience of using ten miles of road whose interests are directly opposed to it. The present charge for transporting coal over these ten miles, as appears from the published rates, is one dollar and twenty cents per ton,—or forty per cent. more than the entire charges by your Road to Allentown, which will yield your stockholders eight per cent. upon their investment. Is there any probability of the charge upon these ten miles of the Reading Roailroad being reduced, to divert its own tonnage to a rival road?

Admitting that the charge upon the portion of the Reading Road used, will be only what the experience of the last five years has demonstrated to be the actual cost, and adding its proportion of interest,—the cost of transportation to Allentown will compare as follows:

Cost of transporting coal per ton, from Mt. Carbon to Allentown, by Schuylkill Haven and Lehigh River Railroad, and Lehigh Valley Railroad.

By Schl. Haven & Lehigh River Railroad—32 miles of 20 feet grade—transporting 500,000 tons per annum @ 104-100 c. per ton, per mile,	33,28	
Interest on road and machinery, 1,000,000 @ 8 per cent. on 500,000 tons per annum, ...	16,00	
Charge for change of motive power, . . .	10,00	
		59,28
By Lehigh Valley Railroad—21 miles of level road—transporting 1,000,000 tons per annum, @ 75-100 cents.	15,75	
Interest on road and machinery, $8,000,000, @ 8 per cent. on 1,000,000, tons on 21 miles, ...	11,00	
		26,75
		86,03

Cost of transporting coal per ton from Mt. Carbon to Allentown, by Reading Railroad and Auburn and Allentown Railroad:

By Reading Railroad—10 miles of level road, transporting 2,000,000 tons per annum, @ 6, 09 ct.	6,90	
Interest of $19,000,000 @ 8 per cent.—on 2,000,000 tons,—75-100 cts. per ton—1-9th of distance, ...	8,44	
Charge for change motive power	10,00	
		25,84
By Auburn and Allentown Railroad,—40 miles of 12 ft. grade, transporting 500,000 tons per annum, @ 96-100 cents, . . .	38,48	
Interest on road and machinery, $2,000,000 @ 8 per cent. on 500,000 tons	32,00	
Charge for change of motive power	10,00	
		80,48
		105,82

Difference in favor of Schuylkill Haven and Lehigh River Railroad 19-79 cts. per ton.

This difference is sufficient to establish the superiority of your Road, and will place it beyond the reach of rivarly as an avenue for Schuylkill coal to the Eastern markets.

How will your Road compare in cost of transporting coal with the new Railroad avenue from the Lackawanna region to New York? By applying the data furnished by Mr. Steele, the cost of transportation by the Delaware, Lackawanna and Western Railroad, New Jersey Central Railroad, is as follows:

Cost of transporting coal per ton from Scranton to New York, . Cents.	183,15
Interest on Del., Lack. & Western R. R., and New Hampton Railroad, $4,000,000, @ 8 per cent., on 500,000 tons coal per annum—per ton,	64,00
Interest on New Jersey Central Railroad, $5,000,000 @ 8 per cent. on 1,500,000 tons per annum, per tons, ...	26,67
	$2,73 82
Cost by Schuy'l Haven and Lehigh River, Lehigh Valley and N. Jersey Central Railroads, ...	2,08 75

Difference in favor of your Road and its connections, of 65-07 cts. per tons.

The above comparisons show that by the construction of the thirty-one miles of Railroad from the Schuylkill to the Lehigh, which your act of incorporation covers—Schuylkill coal can be placed in the New York market in twenty-four hours from the time it is taken from the mines,—at all seasons of the year,—at a saving of from fifty to seventy cents per ton on the cost of transportation, and pay fair dividends to your stockholders, and to the stockholders of the connecting roads.

They show that by the construction of your Railroad, Schuylkill coal can command the Eastern markets in competition with the coal from any other region, and leave handsome profits in the pockets of our coal operators.

They also show the importance of the short and inexpensive link of railroad yet to be constructed to realize these advantages to the coal trade both at home and abroad.

The foregoing remarks will suggest the following conclusions:

That your Road will admit of as favorable grades, and have a less distance of road to construct, than any other outlet for Schuylkill coal to the Eastern markets.

That it will connect directly with the coal-carrying roads of the coal region, and will be entirely clear of any opposing interests.

That it can be constructed for less than one half the cost of any other road having similar connections.

That it is the most favorable connecting line for the Lehigh Valley Railroad to secure the Schuylkill coal trade, and will be one of its most important tributaries.

That it has an abundance of business both at present and for the future, to warrant its construction and ensure its stockholders ample dividends.

That the distance by your Road from the coal mines of Schuylkill county to Eastern markets is much less than by any existing line.

That it can transport coal at much less than present rates on existing lines, and pay dividends.

That it can transport coal at less rates than any other proposed Railroad for connecting the Schuylkill and Lehigh, and pay dividends.

That it can place Schuylkill coal in the Eastern markets on more favorable terms than Lackawanna coal can be placed there by the new avenues for that coal, and pay dividends.

That it will be a vast benefit to the Coal Trade of Schuylkill county,—and That it will be a safe investment for its stockholders.

All of which is respectfully submitted for your consideration.

ALEX. W. REA, *Civil Engineer.*

Schuy'l Haven, Nov. 15, '56.

NEW CREEK COAL COMPANY.

The Philadelphia *Journal*, in announcing the suspension of coal operations by the New Creek Coal Company says:—

We are informed that the New Creek estate will probably find its reanimation in the iron manufacture. Never was a locality more favorable. Besides the juxtaposition of ores, fuel and fluxes, so highly valued by iron men, the position is midway between the Atlantic and the Ohio, right in the line of connection with the leading railways of the State, which would seem to secure enough demand, at prices which tariffs would little affect for a large production. It is expected that the company will put up one experimental furnace soon, and be guided by the results. This will be a safe and economical mode of proceeding, and will be more creditable to the company than a masterly inactivity, which will be a consuming moth upon its effects. The market value of this stock is $1 for $10 par. Its indebtedness is chiefly in six per cent. bonds, of which less than $100,000 have been issued. For there is no market whatever, because they are not known, and they are mostly held quietly by its friends and shareholders. Their coal property is held in trust for its redemption by wealthy and reliable citizens here, who are known to our community. The value of the stock depends entirely on the management. If the iron business be not undertaken, or if, being tried, it shall fail of success, we must look beyond into the regions of new discovery for means to give it value.

BRECKENRIDGE COAL COMPANY'S WORKS.

Extensive fire-proof works have been erected at an expenditure of $60,000, capable of containing thirty retorts, with the necessary tanks, stills, &c., for refining the crude oil. Of these, twelve retorts have been in operation for some months, and the remaining eighteen are ready. The operations of the Company have been very much embarrassed by the unusually low stage of water in the Ohio River, which, by entirely suspending navigation, has detained the additional stills of the Company at Louisville, and prevented the shipments of oil. The Company have now on hand 45,000 gallons crude oil and 5,000 gallons of refined, and are manufacturing at the rate of 6,000 gallons per week. The accumulation of crude oil is occasioned by the want of the stills detained at Louisville by low water. When these stills arrive, and the remaining eighteen retorts are brought into use, the product of the Company will be 15,000 gallons crude or 18,000 gallons refined oil per week. This would give 780,000 gallons, or 19,500 bbls. per annum. The substances obtained by the distillation of each ton of this coal are, burning and lubricating oils, benzole, naphtha, parafine and residuum of asphaltum. The coke left after the operation is used for fuel under the retorts and stills, and is ample for that purpose. Every ton of coal produces 70 gallons of crude, 70 gallons of refined oil.—*N. Y. Tribune.*

IRON AND ZINC.

STATEMENT,

Exhibiting the quantity and value of all importations of Iron and Steel, and Manufactures of Iron, and of Iron and Steel, into the United States during the six months ending December 31, 1855.

ARTICLES.	QUANTITY.	Tons. cwt	VALUE.	AVERAGE VALUE PER TON.
Manufactures of Iron, and iron and steel.				
Muskets and Rifles	3,120 No.		16,718	
Fire-arms, not specified			328,566	
Side-arms			1,757	
Needles			122,821	
Cutlery			726,103	
Other manufactures and wares not specified			2,015,430	
Cap or Bonnet-Wire	79,112 lbs.	35 6	2,365	67 00
Nails, Spikes, Tacks, &c.	737,948 lbs.	329 8	43,288	131 41
Chain Cables	7,870,685 lbs.	3,513 14	235,007	66 88
Mill-Saws, Cross-cut, and Pit-Saws, No.	12,985 No.		35,795	
Anchors and parts thereof	472,618 lbs.	210 19	19,315	91 58
Anvils and parts thereof	439,175 lbs.	196 1	20,833	106 26
Iron.				
Bar Iron	1,101,789 cwt.	55,089 9	2,733,939	49 62
Rod Iron	62,706 cwt.	3,135 6	149,834	47 78
Hoop Iron	4,572,709 lbs.	2,041 7	122,958	60 23
Sheet Iron	14,883,901 lbs.	6,644 5	367,600	55 32
Pig Iron	596,793 cwt.	29,839 13	604,339	20 25
Old and Scrap Iron	145,087 cwt.	7,254 7	111,514	15 37
Railroad Iron	1,797,097 cwt.	89,854 17	3,449,720	38 39
Steel				
Cast, Shear, and German	76,183 cwt.	3,809 3	767,652	201 50
All other	50,460 cwt.	2,523	390,174	154 64
Total value			12,265,768	

CRYSTALLIZATION OF WROUGHT IRON.

This peculiar change in wrought iron, is a subject well worthy the most careful examination, at this time when wrought iron is every day becoming more and more used. That certain causes produce a change in the iron by which its strength is greatly diminished, and its fibrous quality destroyed, without any perceptible external change, the observations both in England and France leave us no room to doubt; and it is of the last importance, that these causes should be well defined, and if possible, the time during which wrought iron can be subjected to them without incurring risk of fracture, determined by observation and experiment. The fracture of axles of locomotives and cars is not uncommon, and many lives have been destroyed by this accident, which has frequently happened in the ordinary working of the road, without any increase in the average load or speed, and without any previous sign of weakness. The experiments published show that when subjected to shocks and torsions wrought iron has a tendency to assume a crystalline state, and become brittle: this change may also be produced by magnetism and heat, and by the process of manufacture.

Mr. Hood, at a meeting of the Institution of Civil Engineers in England, stated that a large anchor, which had been in store for more than a century at Woolwich Dock, and was supposed to be made of extremely good iron, had been recently tested as an experiment, and had broken instantly with a comparatively small strain. The fracture presented large crystals. In this case, Mr. Hood believed that this effect was produced by magnetic influences dependent on the length of time the iron had been in the same position.

Mr. Low stated that at the gas works under his direction, wrought iron

fire bars, though more expensive, were generally preferred. A pan of water was kept beneath them, the steam from which would speedily cause them to become magnetic. He had frequently seen these bars, when thrown down, break into three pieces, with a large crystalline fracture. The same change may be produced in any piece of wrought iron by heating and rapidly cooling it by dipping it in water for a few times.

This change is also often produced in iron by hammering it when below a welding heat, and in forging intricate pieces of iron-work, the ends have frequently been jarred off while the other were being hammered. The larger the piece of iron is, the more difficult it is to keep it at an uniform heat, and the more likely this change is to take place; and we have lately learned from an English paper, that "Mr. Nasmyth's wrought iron gun has proved a complete failure; and this, not on account of the mechanical difficulties which had to be encountered—formidable as they were—but from an unexpected peculiarity in the material employed, when brought together in so large a mass as was necessary for Mr. Nasmyth's purpose. It seems that wrought iron, so tractable under all ordinary conditions of working, cannot be welded together in very large masses without undergoing a change in its molecular arrangement, exceedingly injurious to its tenacity. As we understand the explanation we have received on this point, an immense mass of iron, like that which Mr. Nasmyth has welded together, continues so long in an incandescent and soft state, that a process analogous to crystallization takes place within its substance, whereby the fibrous texture, from which it derives its tenacity is destroyed, and it becomes even less capable than cast iron of resisting the explosion of a heavy charge of gunpowder. We understand that, in addition to the unfavorable result obtained by Mr. Nasmyth at Patricroft, another experiment of a similar nature, made under the direction of government, has proved a complete failure from the peculiarity in the material to which we have alluded; and a large gun which had been completed was found utterly unfit for use. Indeed, we believe it burst into many pieces on the first trial. Mr. Nasmyth's experiment has consequently been abandoned."

The explosion of the large wrought iron gun on board the United States ship Princeton, some years since, was doubtless owing to the same cause.

Concussion alone, if long continued, will produce this change. A small bar of good tough iron was suspended and struck continually with small hand hammers, so as to keep up a constant vibration. The bar, after this experiment had been continued for some considerable time, became so exceedingly brittle, that it entirely fell to pieces, under the light blows of the hand hammers, presenting throughout its structure a highly crystalline appearance.

The cold hammering of railway axles sometimes produces crystallization in the same manner as in the experiment just cited. In order to test this, Mr. Nasmyth subjected two pieces of cable bolt iron to one hundred and sixty blows between sways, and afterwards annealed one of the pieces for a few hours. The unannealed piece broke with five or six blows of the hammer, showing a crystalline fracture, while the annealed piece was bent double under a great number of blows, and exhibited a fine fibrous texture.

The shocks which the axles of road vehicles experience in use sometimes occasion this change, though the process must be very slow, when compared with that of railway axles. The wheels of cars and locomotives being fixed to the axle, and the axle rotating is much more liable to this change from various causes. Where the wheel is of cast iron, the different vibrations of the two different materials seem to facilitate this change, and in this country, where cast-iron car wheels are to a great extent used, the fracture generally takes place close to the wheel. Owing to the rapid rotation of the axles they become highly magnetic, and there seems to be a close connection between magnetism and crystallization. The presence of steam seems to have an influence in producing this change, owing perhaps to the development of electricity, and this may have a great effect upon the axles of locomotives.

The severe winters of New England, as well from the action of frost on

the iron axle, as from its effect in making the track rough, doubtless has a tendency to hasten the process of crystallization, and to produce fracture in axles affected by this change. We have known of the fracture of the axles of the driving wheels of two locomotives occurring on one road in New England, in one week during the month of February, 1856. One of them was broken close to the wheel, and the whole surface from the centre to within an eighth of an inch of the circumference presented a bright granulated appearance; a narrow rim extending round the whole axle looked smooth and of a duller color, as though it had been fractured for some time.

From the fact that this process of crystallization appears to begin in the centre of the axle, and from a belief that the effect of the blows and concussions which an axle receives, would be greatly diminished if the axle was made hollow, this plan has been tried upon several English roads, with a highly encouraging result. A hollow and a solid axle have been run hot in a lathe for two hours without oil, at a speed corresponding to twenty miles an hour travelling; the solid journal broke off, with 179 blows, quite short and crystalline, but the hollow journal would not break transversely, and longitudinally in several places with 400 blows, without any appearance of change in the texture of the iron.

There seems to be no doubt that under certain circumstances wrought iron is liable to undergo a change by which its strength and tenacity are destroyed, and that railway axles are in a special manner liable to this change.. Some of the causes or supposed causes of it, we have briefly alluded to; not with sufficient fulness perhaps, to afford much valuable practical information, but enough so, we trust, to lead others, with better opportunities and greater abilities, to investigate this subject, so important in its bearings both on the safe and the economical working of railroads.

MANUFACTURE OF MALLEABLE IRON, &C.—BESSEMER'S PROCESS.

These pages have already contained an extended description of Bessemer's invention, as well as some of the criticisms which have been made upon it. Although there may be some who regard with little seriousness the invention, while others attach to it an exaggerated importance in view of our present information upon the subject; yet, it should be stated that the most scientific and intelligent ironmasters are still inquiring relative to its nature and value. The conclusions to which they may arrive, whatever may be the opinions of others, will, doubtless, present the true character and results of the process. Meantime we find in the sheets prepared for the members of the American Iron Association, the most complete and satisfactory sketch of the course which discussion has taken upon this subject, and at the risk of repeating a few particulars, heretofore published, we lay it before our readers engaged in the iron manufacture, as an interesting statement;—

The paper which Mr. Bessemer read before the annual meeting of the British Association in August last, and which has already been put into the hands of the members of the American Iron Association, was extensively copied or noticed in the newspapers of Europe and America. The *Scientific American* gave its substance on page 6 of the first number of its twelfth volume, and has followed up the subject in every succeeding issue by criticisms and private letters. In the second number, page 13, it quotes the *London Times*, refers to the praises of Nasmyth and Rennie, and describes the experiment of the 22d August, at London, upon 834 pounds of melted pig, with a blast of 8 pounds, the tapping taking place in 24 minutes, and producing an ingot of 792 pounds of cast steel, pronounced satisfactory by eminent iron manufacturers present.

In No. 3, p. 21, the credit of the invention is withdrawn from Bessemer,

and assigned to J. G. Martien, formerly of Newark, N. J., now residing in London, a practical metal worker, who claims to have produced all Bessemer's results long before, by operating in the presence of John Christopher of Newark, now of Pittsburg, and others, upon 2,000 pounds of crude melted iron, tapped in six minutes, and producing refined carburet of iron, some of which was very malleable; that he instructed his legal agent in London to include the discovery in a patent then taking out—viz., the principle that air made to penetrate and *search* every part of a body of melted iron would refine it and make it malleable; but that this legal adviser omitted to do so, and appears now to be interested personally in Bessemer's patent, which uses the same term of *searching*, by which Martien's process was most characteristically described. The patent which Mr. Martien did obtain September 5th, 1855, was for improving the manufacture of iron and steel, by the application of air or steam below the surface of the melted iron flowing from the furnace or refinery, in any such manner as will compel a thorough searching of the mass, prior to congelation, for the better purification of the metal. In his claims Mr. Martien is said to be sustained by powerful English iron manufacturers, by public sentiment, and by registered papers in England and in this country.

In No. 4, the *Scientific American* urges Martien's claims to priority by giving two drawings of Bessemer's Furnace, or converting vessel (from the *London Illustrated News* of September 6, copied from Bessemer's Specification of 7th June, 1856), and two of Martien's vessels, from Martien's Specification of March 11, 1856, by which it is evident that their processes are the same, but that Bessemer's apparatus is the more complete, inasmuch as Martien sends the air-blast to the bottom of the iron by a tuyere thrust downwards through the lid, while Bessemer applies tuyeres to the bottom of the sides as in common blast furnaces. It is well known that James Nasmyth, the distinguished inventor of the direct action steam hammer, invented a similar application of steam to be blown through molten iron while still in the smelting or puddling furnace, but only to obtain a certain *mechanical* end, connected with the better handling of the metal, and failing to produce even the desired effect by chilling the mass. It seems that this process of Nasmyth's was also patented in this country by H. W. Woodruff, of Watertown, N. Y., 9th October, 1853.

In its 6th number, p. 43, the *Scientific American* gives a letter from William Kelly, Suwanne Iron Works, Eddyville, Ky., 30th September, 1856, claiming precedence of both Martien and Bessemer, and stating that he commenced experiments in what he called at that time "air-boiling" iron, in November, 1851, with the intention of expelling the refractory carbon and dispensing with the puddling process. "My first efforts," he says, "were quite satisfactory, as with a blast taken from my furnace, and introduced into a suitable cupola filled with liquid metal taken directly from the furnace, I produced a fair article of malleable iron. I found, when using gray iron, cold blast answered my purposes, but when the metal was white, I found that hot blast had a better effect." His chief difficulty, he says, he has overcome, which lay in a necessity to modify his process to suit the variable qualities of iron yielded by his charcoal cold blast furnace. He asserts that hundreds of persons came to witness his trials, and the whole subject was thoroughly discussed by iron men present, among whom were English puddlers, who had come to examine his process.

In this conflict of claimants for the honor of an invention, we have additional evidence that inventions are the growth of an age of progress in any direction which human energy may happen to take, by which certain wants of the time are felt by, and the mode of applying them suggested to, more than one practical man at one time. The slightest suggestion to a prepared mind is sufficient to start the whole train of ideas involved in some grandly simple but novel method of producing what many have imperfectly obtained by previous inferior methods. It interests us much more, therefore, to know what the best men think of the feasibility of the boiling process, than to de-

cide who first thought of it or tried it. Henry Bessemer's name stands affixed to the following list of English patents; and therefore his antecedents justify his admirers in crediting him with the genuine authorship of this invention, whether Martien, Kelly, or anybody else ever made the same or not. But the legal difficulties in the way of purchasing his patent will be seen from John Avery's letter of August 19, Paris, to the *London Mining Journal*, No. 1096, republished in the *Journal of the Franklin Institute*, Philadelphia, October, 1856, p. 285, in which he says—"It may be well to mention, that Mr. Martien has publicly proved his invention in Britain prior to the date of Mr. Bessemer's patent."

Mr. Bessemer took out three patents May 4, 1853; three September 21, 1853; and one January 27, 1854, for improvements in apparatus for concentrating cane juices, &c.; one August 19, 1853, for improvements in the manufacture of water-proof fabrics; one January 26, 1855, and another April 17, 1855, for improvements in the construction and manufacture of guns for throwing projectiles, &c.; one March 27, 1855, and others afterwards, for improvements in the manufacture of iron and steel; the dates being dates of *sealing*, under which they are to be sought for in the reported lists.

The *Journal of the Society of Arts*, September 19, 1856, p. 708, gives a series of specifications of patents successively taken out for the use of steam in the puddling furnace; the first by Reuben Plant, July 18, 1849; the second by James Nasmyth, May 4, 1854; the third by Jos. Gilbert Martien, of Newark, N. J., U. S., September 15, 1855; and the fourth by Mr. Bessemer, January 4, February 12, March 15, May 31, and August 19, 1856.

The *London Mining Journal*, p. 607, says that Plant's patent was fully detailed, with illustrations, in its January 26th, and February 7th Nos., 1850; that the steam jets increased the heat tenfold, forming in fact an oxyhydrogen blowpipe, carried off the gases so detrimental to finished iron, decarbonized the iron, and gave it fibre. The *Birmingham Journal* even gives the credit of using blast air in the puddling furnace to Reu. Plant.

In the *London Mining Journal*, p. 583, a "retired puddler" fiercely attacks Mr. Bessemer's process, and describes his own work under a steam blast puddling patent sixteen years ago, in which he obtained all Bessemer's results, but no malleable iron, He used steam at twenty and even thirty-five pounds to the inch blast. He argues that steam is far better than air, because it contains 88 per cent. oxygen and 12 per cent. hydrogen, while air contains but 23 per cent. oxygen and 77 per cent. nitrogen; dry high-pressure steam containing also enough latent heat to fuse its own weight of cast iron.

Mr. Mushet, in the same Journal, p. 583, refuses to Mr. Martien the credit of having caught the great idea of Bessemer, for had he done so, he could not have occupied himself with the trifle of obtaining fine iron from raw ore, going over the ground of scores of patents—ground which his (Mr. Mushet's) father had worked up sixty years before, and, in fact, had been worked over by all artificers in iron since Tubal Cain. He considers Mr. Bessemer's invention to consist essentially in the burning of the iron to obtain the desired heat. In a subsequent article, however, p. 599, he claims that herein lies the true conception of the inventor; he has raised the after processes of the manufacture to a level with the gigantic and growing proportions of the first or smelting process. When Cort invented the puddling furnace, a blast furnace yielding twenty tons of pig per week, was a prodigious concern; now that we have furnaces which yield more than ten times that amount, the puddling process is wholly inadequate. "Once grasp a great principle, such as is displayed in the decarbonization of cast iron, on this great scale, without fuel and without labor, the minor details are merely matters for time and perseverance. The demand of the age is not for quality but quantity; and, in meeting this, Mr. Bessemer will carry every thing else along with him, quality inclusive, where it is required."

In No. 1100, p. 631, of the same Journal, Mr. Mushet transfers all that he had said in praise of Mr. Bessemer to the credit of Mr. Martien, adding, that

"he had never met any person so extensively and accurately acquainted with the practical science of the iron manufacture." Mr. Martien, in November last, had realized all Mr. Bessemer's results, "before a host of incredulous and astonished spectators," by using eight hundred tuyeres instead of five, and in five minutes instead of thirty, in a vessel that answered to the idea of Mr. Adams's "colander." Mr. Bessemer filed his patent through Mr. Carpmael, the month following. Mr. Martien had already filed, by another person, in September previous, his provisional patent, which permitted him to experiment for six months. In February, 1856, he applied to Mr. Carpmael to file his full specification, who informed him that he could only specify a "gutter," and not a "receptacle," which word was to be stricken out wherever it occurred; yet his provisional filing did not specify "gutter," and his experiments had been made in a "receptacle." Ignorant that a secret provisional patent adverse to his own was already filed, and running its six months, he yielded to English law as his attorney saw proper to explain it, and permitted the language of his final specifications to be altered in such a manner as seriously to compromise his own invention.

In No. 1101, p. 647, of the *London Mining Journal*, Mr. Mushet writes again against Mr. Bessemer, and details his father's experiments and patents, thirty years ago, in granulating iron in water, a process claimed by M. Uchatius, against Mr. Bessemer, but in fact notoriously old. His father's second process was to run finers' metal direct from the smelting furnace, "but it was found to require a nice balance of conditions, which could not be maintained, with the manageable uniformity required on the scale of manufacture;" the metal would not stop at the point required; the want of carbon would introduce a series of decarbonizing reactions; the blast oxygen being consumed in making cinder, there ensued a want of carbonic oxide (a gas not then discovered, nor its use understood) for the upper ore; "the decarbonization of the metal increased to that degree," he adds, "between cast and cast, that I conceive I have seen metal run from that cupola such as no one ever saw, as a regular operation, either before or since:" the conflagration of a cast far exceeded the most fiery run of high-blown metal from a common refinery; the necessary reduction of burden produced vexatious alterations, and the experiments were abandoned, after having run as good malleable iron and steel as any Mr. Bessemer has made; the description of grain corresponds: it was a most unmanageable metal; could be hammered when cold; was too infusible for any subsequent operations, but so red-short that it could be worked up small in a hollow puddling furnace.

In the *London Mechanics' Magazine*, p. 296, September 27, a review of the consecutive patents of Guest, Plant, Nasmyth, Bessemer, and Martien, winds up with a notice of one "analogous but superior to Mr. Bessemer's. The inventor is M. V. Avril," who affects the production from the blast furnace of cast iron, steel, or iron, at will, by—1. A modification of the present blast furnace. 2. Tuyeres round the bottom. 3. Use of pure oxygen; with an economy of one-fourth the fuel necessary to first fusion, and making a cheaper iron than Mr. Bessemer's. The experiments are said to have thus far succeeded, but are not described.

In the *London Mining Journal*, p. 600, Mr. A. M. Perkins claims precedence of Nasmyth in inventing the dry steam puddling blast, having patented it in 1843, and used it in 1850, but only for melting purposes, and is still using it at a pressure of 1500 pounds to the square inch, which does away with the need of a blower.

Mr. C. Sanderson, of Sheffield, an experienced and highly respected iron worker, publishes his opinions of Bessemer's process in the *London Mechanics' Magazine* (alluded to by the *Scientific American*, p. 21, and republished in the *Journal of the Franklin Institute*, p. 273, October, 1856) to this effect—that his experience forbids him to credit the beneficial results of the process; that while he admits that air blown into melted pig iron will *decarbonize* it, he

must still refuse to believe that iron decarbonized thus, is like iron decarbonized by the old puddling process; that it will not admit of being either *drawn under a hammer* or *rolled to a bar;* neither will it, like common cast steel, make a boring tool, or a cutter, a tap or a die; it cannot be fashioned into a needle, or cut into a file; in fine, he is compelled to give an opinion that it is a metal which cannot assume the commercial value of steel. In fact, presuming that cast iron contains five per cent., and steel one per cent. of carbon, it does not follow that by simply depriving cast iron of four per cent. you convert it into steel. Something more is needful; a certain something, perhaps, not yet well understood. Mr. Bessemer's decarbonized iron, under a good lens, shows a mass of metal made up of small bright atoms less affected, combined with larger crystals more affected by the process, a mixture which is neither useful steel nor malleable iron.

On the publication of these opinions of Mr. Sanderson, letters poured in upon the editors of the *London Mechanics' Magazine* in reply, one of which told the following anecdote of what happened at the Baxter House trial:—"A stout, wealthy-looking, growling individual, with a spice of the St. Thomas in him, thought the casting too hot to try with his fingers, but expressed his belief that it was not malleable, but simply cast iron. On this Mr. Bessemer spoke not, but entering the shed, returned with a large axe, thick on the edge, with which he 'laid on load.' Two cuts at the edge of the ingot left the impression in indents analogous to those produced in chopping a wooden post. 'That's no cast iron!' growled some one else, as though wishing it had been; and the Staffordshire iron chieftain, Mr. Blackwell, possessing himself of a piece, subjected it to cold hammering on the anvil, and subsequently to filing in the vice, the file hanging to it as to tough copper." The writer goes on to say—in direct opposition to Mr. Sanderson's opinion—"The existing blast-furnaces of the iron makers, with a functional alteration, are now competent to turn out the malleable iron ready for the hammer or the rolls."—(*W. B. A.* No. 1726, September 6, p. 226.)

Mr. Truran, author of *The Iron Manufacture of Great Britain*, in a letter to the *London Mechanics' Magazine*, No. 1727, p. 249, also commented upon in the *Scientific American*, p. 34, agrees with Mr. Sanderson that the mere purifying of crude iron cannot make malleable iron or good steel. Malleable cool crude iron has often been made, but it is red-short, and has no weld. "Bessemer's exhibited ingots," he says, "were no more like bars of iron or steel than chilled cast iron is like tempered steel."

Mr. Truran claims also to have published in his elaborate work on Iron Manufacture, 1855, all Mr. Bessemer's main facts, as facts well known of old to all intelligent refiners, such as jets of air into the liquid iron used in the old form of the refinery furnace, the combustion of the carbon, and the intense heat generated capable of fusing the bottom of broken sandstone. (See the *Iron Manufacture of Great Britain.**) The only novelty of Mr. Bessemer's method, then, consists in shortening the process by using the first heat of the blast furnace, aad thus saving the fuel of the refinery. He blows but half an hour; ordinary refining occupies two hours, and the heat is kept up by a covering of coke or charcoal. Mr. Truran ridicules Mr. Bessemer's idea of first making an oxide of a part of the iron by his intense heat, and then immediately melting that oxide to fuse the earthy bases present; for the newly formed oxide is utterly infusible at any temperature until it is brought in contact with carbon (either solid or gaseous) to take off its oxygen. This is accomplished in the refining furnace by covering it with coke; but Mr. Bessemer refuses it all fuel, and therefore all carbon, and so the oxide must remain an oxide, and be blown off as such in a solid state, entirely regardless of the earthy bases. This happens in the refining furnace when the iron is not sufficiently covered with incandescent fuel, the atoms of oxide are blown off up the flue in company with silica and other earthy bases. The shower of sparks

* Not yet published in the MINING MAGAZINE.

described in Mr. Bessemer's process are these atoms of oxide of iron, silica, &c., blown off from his "converting vessel," and make up his percentage of loss.

Mr. Truran also ridicules Mr. Bessemer's claim to make "charcoal iron" by his process, on the ground that no *mineral* fuel is used in it; seeing that in the refinery furnace the quality of the fuel has very little influence upon the quality of the iron, because they are kept separate, and while the solid impurities of the fuel pass off in the cinder, the gaseous impurities (sulphur, phosphorus, &c.) pass off up the flue. "Charcoal iron" is a quality of pig iron, and cannot be got out of bad pig by any subsequent process. [This, however, seems to be begging the question, and unfair to Mr. Bessemer, who claims to *get rid of* all sulphur, phosphorus, &c., by his process, so as to leave his bad pig in the condition of good charcoal iron.]

Mr. Truran argues from Mr. Bessemer's loss of 5½ per cent. in rolling, or 1 cwt. per ton, that his iron cannot be so very pure after all, since the ordinary loss in rolling, by the squeezing out of the impurities, is but 15 to 16 pounds per ton.—(*London Mining Journal*, No. 1098, p. 599.)

J. S. Miner, Mott Haven, N. Y., writes to the *Scientific American*, No. 6, p. 43, to the same effect, basing his views upon the tabulated analyses of different qualities of iron and steel. This writer asserts dogmatically that *pure* iron is not what manufacturers require or want. If his tables are correct, he shows that the best English razor steel (*a*) is not so pure as English crude iron. (*b*) :—(F. means iron; C. carbon; Si. the metallic base of sand.)

(*a*) F. 93.80, C. 1.43, Si. 0.52, Sulphur 1.00, Manganese 1.92, Arsenic 0.93, Antimony 0.12, Nitrogen 0.18.

(*b*) F. 94.63, C. 2.60, Si. 1.53, Sulphur 0.85, Manganese 0.50, Phosphorus 0.89.

And that the purities of Swedish (*c*), English refined (*d*), and German (*e*) iron are *inversely* as their strength :—

(*c*) F. 98.78, C. 0.84, Si. 0.02, Manganese 0.05, Arsenic 0.02, Copper 0.07, broke with 72,000 pounds to inch.

(*d*) F. 98.90. C. 0.41, Si. 0.08, Maganese 0.04, Phosphorus 0.40, broke with 55,000 pounds to inch.

(*e*) F. 99.87, C. 0.09, Si. 0.03, very soft and weak.

Unknown differences of ore and fuel, in the blast furnace, determine these essentially important practical differences in the iron, and not differences in its subsequent manipulation. It is the fine magnetic ore of Danemora which makes its iron superior to iron of the ores in the neighborhood, handled in the same way. Berzelius even detected as much as 18.00* per cent. of silicon in one kind of really malleable and useful bar iron. The best bar contains impurities. Steel is in fact ruined if its silicon be withdrawn or oxidized into silica. Perfectly pure bar is pale, soft, and weak; in a word, worthless. Iron is, therefore, made malleable not by a purifying, but by a fiberizing process, in which the remains of cinder in the iron plays a most important part in being brought also into fibre, and thus strengthening the fibres of iron. A fine malleable and fibrous structure can only be given to iron by a tough cinder and manipulation.

Mr. Miner like Mr. Truran attacks Bessemer's chemical hypothesis, that so much of the iron as is burnt to an oxide by the extreme heat of his process, will form a powerful solvent of those earthy bases that are associated with the iron—that is, will eat up the silica, alumina, lime, &c., and leave the unoxidized iron pure—but on the ground that the same flame which *oxidizes* iron is not hot enough to *melt* the oxide when formed. Mr. Miner claims to have obtained the desired improvements on the ore manipulation process of obtaining wrought iron from the ore direct, at the works of the American Magnetic Iron Company, under his direction.

* As this extraordinary assertion was repeated in the *Philadelphia Ledger* of Oct. 31, it is necessary to give it as it stands in Miner's letter to the *Scientific American*. But it is probably an original mistake for 1.8 per cent. of silicon; or else a misunderstanding of Berzelius's language for 18.0 per cent. of the siliciuret of iron (a mixture of iron and silicium), which would be equal to 8.0 per cent. of silicium.

D. Mushet (*London Mining Journal*, p. 598) says that we know nothing of the cause of the peculiar excellence of Swedish iron. His father discovered that the best Swedish and Russian bar iron contained an appreciable alloy of carbon, but we are not to suppose that that gives it the quality; it is the possession of quality from some unknown source which enables it to bear an alloy which would injure the tenacity of common iron. The qualities of Mr. Bessemer's iron we cannot predict; it is a matter of experiment.

Mr. Collyer describes in the *London Mining Journal*, p. 615, the bar exhibited at the Baxter House experiment, as about twelve feet long, one-half inch thick, by two inches wide, showing great ductility when bent, but not a corresponding grain when fractured. To get rid of the phosphorus, Mr. Collyer suggests a mixture of pulverized anhydrate of lime in the blast, by which phosphate and silicate of lime would be blown off in the slag. The minutest quantity of arsenic in gold, silver, and copper, will destroy the malleability of these most ductile of metals; and, therefore, arsenic in iron may be the element of mischief, for which, hitherto, sulphur and phosphorus have been mistaken. He compared fragments of Bessemer's ingots with those of pig iron, and refined iron, and found the particles manifestly purer and compacter.

On p. 624 of the *London Mining Journal*, No. 1099 (copied from the *Journal of Soc. of Arts*, September 12, 1856), we have the first account of experiments subsequent to the first heat of the discussion. It comes in the form of a communication to the Secretary of the Society of Arts, from the Royal Arsenal, Woolwich: 1. A mass, fifteen inches by six and a half square, made from Blænavon pig, as it came from the ingot mould, heated in a scrap forge, and bloomed under a one ton Nasmyth hammer, showed the usual cold fracture, *crystalline*, porous, and brilliant. 2. The bloom worked very stiff and rigid, and was rolled into a bar two inches wide by five inches thick. Cut with the shears, when hot, a good incision was made to about one-third of the thickness, and the remainder fractured in the operation. Another portion, hammered to a short inch square bar, when cut hot presented the same result. 3. The first bar, cold, once hammered and once rolled, had a nick cut all round, and was broken short off on receiving a blow from a hammer. The fracture clean, laminated as if the crystals were squeezed by the pressure into horizontal layers: no fibre. 4. The two portions fagoted, heated and hammered into a cylinder of one inch diameter; nicked all round; broken with a blow; a clean fracture; no fibre; the first crystalline appearance restored, as if the crystals had been simply pressed back by hammering in a direction contrary to the first. 5. The two portions fagoted, heated and hammered to the same dimensions; a slight nick made on one side, fractured by a blow, with the same results. Impressions of the fractured end were taken in lead, and when compared at each fracture, had the same appearance with no increase of fibre. 6. One portion of the last made bar accurately turned and placed in the machine for testing the tensile strain. First part of the fracture looked oxidized and not elongated. The iron worked harsh and rigid under the hammer, but well and pleasantly in the lathe. Diameter of line of breakage, in the following means of two specimens each, 6 inch.

	Breaking weight in pounds to square inch.	Elongation before fracture. Inch.	Diminution of diameter before fracture. Inch.	Fracture.
Magnetic Nova Scotia wrought iron	66.491	1.09	.123	Fibrous.
Catalan hematite and Nova Scotia specular wrought	59.594	.382	.19[illegible]	"
Nictau magnetic wro't iron	67.905	.289	.146	"
Nictau shell ore wrought iron	61.089	.234	.204	"
Bessemer's iron, heated and rolled once, heated and hammered four times, but laminated to the last.	65.999	.113	.014	Chryst. partly oxidized.

A chemical analysis of a fragment of Bessemer's iron carefully selected from the solid interior before blooming to avoid cavities, fissures or fused oxide, gave not a trace of silicon, nor of graphite, nor of uncombined carbon; 0.3 of combined carbon; .44 of phosphorus; 0.056 of sulphur. A similar analysis had been previously obtained from other iron furnished by Mr. Bessemer. Blænavon iron is comparatively free from these last impurities; a random specimen, under the same treatment, yielded 0.48 phosphorus and 0.062 sulphur. It appears, therefore, that while the uncombined carbon and silicium are completely removed by the oxidizing process (their oxidization being probably almost concomitant), the complete removal of the combined carbon is a matter of greater difficulty, and that the phosphorus and sulphur are but little affected, requiring, in fact, longer treatment than the process allows.

In the next number of the *Journal of the Society of Arts*, Sept. 19, p. 714, is a review of the above experiments, by W. Bridges Adams (copied into the *London Mining Journal*, No. 1100. p. 640, and into the *London Mechanics' Magazine*, p. 270), in which he alludes to his letter in the *Times* of Sept. 9, and the bar therein described as fifteen feet long, two inches wide, and bare half an inch thick, one end of which he says was bent round cold to a circle of six inches diameter, displaying considerable toughness, and broke on being bent back again, with a white large-grained crystalline fracture. To the file the iron is perfectly soft, without "pins," or hard particles, and with the back edge of a penknife small filaments are easily removable; these are mechanical indications analogous to those of charcoal iron. The quality appears to be homogeneous, but the lamination shows want of solidity or porosity; yet it takes a beautiful polish. He remarks that it is an important fact, that by these experiments this crystalline iron should exceed in strength two of the above tried fibrous kinds of iron, and approaches nearly the other two, because, for many purposes, granular iron is preferable to fibrous, as for rail-wheel tyres, where fibre laminates and strings. Bessemer's blast being kept up to the very last to keep the tuyeres clear, the iron when poured out is aërated like champagne and must be porous, nor will hammering or rolling reach the innermost pores. Some way to cure this evil must be found. Iron and brass castings are made after resting and under a head to squeeze out the air bubbles. A vacuum ought to be made while the iron is subsiding, and pressure applied as soon as it sets, before transferring it to the anvil or rolls. Fibre in iron, as in wood, may be produced, for all we know, or the microscope has yet discovered, by some intervening substance. [Mr. Adams here half indorses Mr. J. S. Miner's views given on page 510 above.]

Mr. Adams reports, that a chemist has repeated Bessemer's process in a common clay tobacco pipe. He urges upon government to experiment with system.

Other experiments by Mr. Clay, manager of Messrs. Horsfall's Mersey Steel and Iron Works, and the makers of the monster wrought iron gun recently presented to the government, are reported on p. 941, Sept. 20, of the *London Mining Journal*, as unsatisfactory. The specimen had all the appearance of burned and imperfect cast iron, "rotten hot, and rotten cold." Mr. Dawson corroborated Mr. E. Jones's statement before the Polytechnic Society of Liverpool, and stated that, to his own disappointment, the portion submitted to the rolling mill had proved in every way intractable. Mr. Jones said that the iron was said to have originally cost £6, but, after being operated on, he did not consider it worth £4 per ton.

The *American Railroad Journal*, Nov. 1, p. 699, gives an extract from an English paper with "the latest information" in reference to the process. "A sample of railway bar, made at the Dowlays works, may now be seen at Mr. Bessemer's office—a foot-rail; 60 pounds to the yard; originally 22 feet long, reduced by sample cuttings to 17; formed from a single ingot 10 inches square, twice heated, fourteen times rolled; tested, and found thoroughly good. The expense of making this rail could not have been more than one-half the usual

cost. So far as the quality of bar goes, we think nothing remains to be desired. We have also examined tin plate manufactured by Phillip, Smith & Co. at the Dafen Tin Plate Works, Llanelly, and their appearance indicates a quality quite equal to that made from charcoal iron. A large majority of the tin plate manufacturers at Gloucester on the 1st inst., bore testimony to the excellence of the samples. Mr. Smith stated he had never before produced tin plate so thin, of a thickness only equal to that of writing paper (the thinnest tin plate yet made has been in button manufacture); thirty-two sheets were rolled in one pile by successive doubling, but being red-hot at the time, were separated with difficulty; some beautiful samples were, however, obtained, some of them polished black by the rollers. Nothing but the best iron could possibly stand such a test as that to which this was submitted in the production of these plates, for which no use is at present known, but they seem adapted for ornamental work. The Russians, who have been familiar with iron paper since 1851, may afford some hints how to apply these sheets to good use."

JOURNAL OF GOLD MINING OPERATIONS.

DESULPHURIZATION OF GOLD ORES.

The following is an extract of a letter from Dr. Homer Holland, the patentee of the process for the desulphurization of ores by the use of the nitrate of soda:

"I have been constantly at experiments in igniting and resolving argentiferous and auriferous ores and arsenides, sulphides, tellunides and selenides, and have confirmed the value and feasibility of my first device, and made many new and valuable improvements in metallurgic resolving, lixiviation and separation; all dependent on proportioning and igniting with nitrates, with unexplosive cases, like soda, lime, magnesia, bargle and lead. You sent me one number, February, I believe, of your magazine, containing an interesting article fromMr. Leeds, at Rutherford, N. C., mine, in which he promised further accounts of the various methods of treating gold ores and extracting gold.

I have been delayed in introducing my process by several very serious contingencies.

There is and has been no practised method of separating ores from the sands and slime in this country.

The nitrate of soda has been greatly enhanced in price by the Russian war.

There is no direct railroad or other intercommunication between the mines of Virginia and North and South Carolina, and the nitrate of lime and nitrates of magnesia and lime of the caves of Tennessee and Kentucky.

If I am not able to employ the nitrate of lime, and nitrates of magnesia and lime in direct ignition, and the resolution and extraction of gold and copper from the arsenides, sulphides, tellunides and selenides, I could obtain directly from those nitrates, with insoluble bases, and the sulphate of soda resulting from ignition and lixiviation, my nitrate of soda by digesting, cheaply, at any mine.

I am intending to spend five months at the mines south, and hope to demonstrate the ease and simplicity of my processes, as well as their value and feasibility.

At some future and suitable time I trust to give you an acceptable article

on my processes, as in their exploitation. Any thing further would be premature.

My ignition and resolution far exceeds any metallurgic "roasting process," by O. F. Platee, described in his recent volume, 380 pages, published in April, at Friburg, both for copper and gold, as I can so proportion the complicated sulphides, &c., &c., with nitrate of soda, and ignite, as to take out as high as 83 per cent. of pure cement or galvanic copper at a single ignition and lixiviation, and all the gold."

THE NUMBER OF MINES IN CALIFORNIA FROM WHICH RETURNS HAVE BEEN RECEIVED UP TO 1854 AND 1855.

With their depth in fathoms below the water line, and amount of ores in tons reduced; together with the aggregate receipt from the same.

NAMES.	Depth below water.	1854 Ores raised	1855 Ores raised	1854 Receipts.	1855 Receipts.
	feet.	tons.	tons.		
Badger	26		1,080		$35,000
Midian	12		840		9,000
Union	21		1,000		18,000
Keystone	23	2,204	8,000	$52,000	60,000
Eureka	17	1,400	1,296	48,000	33,000
Pacific	9		1,924		89,000
Experimental	4		1,000		12,000
Mammoth	8	1,095	1,095		28,000
Spring Hil	17	900	2,074	20,000	46,000
Herbertville	28	8,400	1,200	72,000	20,000
Rocky Bar	14	1,200	1,000	47,000	40,000
Boston		2,088	2,674	82,000	86,000
Osborn Hill	12	4,650	8,120	104,000	78,000
Empire	12	5,200	4,680	180,000	116,000
Mt. Was ngton	16	2,670	986	56,000	22,464
Helvetia Lafayette	14	4,160	4,000	100,000	74,000
Marble S ings	9	To date.	4,820		56,197
Pittsburg	8	8,000	1,000	112,000	19,000
Totals				$777,790	$2,239,161

Total for 1854 and 1855 .... $3,016,951.

SULPHURETS OF IRON FROM QUARTZ CONTAINING GOLD IN CALIFORNIA.

These sulphurets were taken from the tailings of mines in different parts of California, and examined, to detect any metallic gold that might be contained in them.

The process pursued to extract the metal is one that would be practicable on the large scale, and was adopted as a means of illustrating the practical results obtainable by those means if fully carried out, and long since suggested.

A detail of the process may not be amiss, though containing nothing that is new.

The sulphurets were separated from the sand by washing, and dried. After being thoroughly dried, they were introduced into a shallow porcelain capsule and roasted at a clear red heat, being constantly stirred, and the heat continued until all fumes of sulphur were dissipated. The mass at this time has the appearance of a coarse brownish-black powder, which, on being reduced to a fine powder, presented all the appearances of being entirely peroxidized, and in this state was of a red iron-rust color.

It is to this condition that it is necessary to bring this mineral, in order to extract any gold by amalgamation that it may contain.

After thus reducing to a powder the calcined sulphuret, it was washed and amalgamated, and from the amalgam the following results were obtained:

The quantity used being one ounce avordupois in each case.

Spring Hill Mine gave	6-8ths grain,	equal to	$270	per ton.
Mt. Washington Mine, "	3-16ths	"	135	"
Osborn Hill Mine, "	5-16ths	"	225	"
Empire Mine, "	1-8th	"	90	"
Eureka Mine, "	3-16ths	"	135	"
Badger Mine, "	1-9th	"	80	"
Lafayette and Helvetia Mine,	1-8th	"	90	"

The grain of gold in these cases is estimated at the value of three cents, its fractional value being omitted.

The results are what may be expected in mill work, if properly conducted, and do not represent the absolute amount of gold contained in these minerals. Chemical analysis will show a much greater amount of metal, and would have been presented in connection with the above had it been completed in sufficient time for this report.

I am well persuaded, that if the above process had been conducted with that strict care pursued in close and rigid investigations, that at least twenty-five per cent. would have been added to the above figures. My object was to present the probable amount of gold that might be expected, from the reduction of those minerals by a similar process on a large scale, and which are now rejected and thrown away.

It would be difficult to estimate the amount of gold that is thus thrown away each year from these mines, but a comparison of the average yield of the ores of the mines of the State generally, will show that the amount is certainly very large.

The yield of these sulphurets is about seven times greater than the produce in the first instance in the majority of the cases, and they compose about twenty per cent. of the ores as they come from the mine. This being the case, we certainly sustain a loss of at least two hundred per cent., above the aggregates that are realized from the working of these ores, which would place the amount of metal that escapes equal to six millions of dollars from the eighteen mines, whose operations are reported for 1855.

I have repeatedly suggested to miners the saving and separation of these sulphurets, by those means that are used for the separation and saving of metallic minerals less dense than the sulphurets of iron, and much less valuable. But, as yet, no such means have been adopted, or, at least, but very imperfectly, and it is to be regretted that more attention is not bestowed upon this subject.

DEEP MINING SHAFT.

A company of miners at Table Mountain, in the vicinity of Douglas' Flat, says the Columbia Clipper, have sunk a shaft to the depth of four hundred feet, and struck a ledge. They have forty feet of pay dirt, but how much it pays is not known, as they keep their prospects a secret. This is perhaps the deepest shaft in the State, and would not be attempted in any other locality than Table Mountain, which promises so rich a reward to the miner.

HYDRAULIC WASHING.

The improved methods of washing for gold are such, that in most places one man can now do as much as eight or ten could formerly. The hydraulic seems to be the perfection of placer mining. By it the water is made to do nearly all the labor. There is no digging, no picking, no handling over the dirt with shovels. A stream of water, under a heavy head, is thrown with violence against a bank, and before this liquid *catapult*, the earth melts away like so much snow before a jet of warm water. It is thus that whole hills are now swept away in an incredibly short period of time, and immense results are brought about with comparatively little manual labor.

THE AUSTRALIAN GOLD PRODUCT.

We extract the following from a letter in the London Times, dated Melbourne, July 9th:—The supply of gold during the last two weeks has been very small, namely:—

Week ending 29th of June,	29,110 ounces.
Week ending 5th of July,	35,523 "
	64,633 "

This is owing entirely to the very unfavorable state of the weather during the last three or four weeks, and especially during the last fortnight. Heavy rains have continued to fall nearly every day. The diggings have been literally deluged, and the state of the roads is such, that from five of the mining districts no escorts whatever arrived last week. All the newspapers of the mining districts announce "incessant rains," whereby "mining operations have been greatly impeded." The Bendigo paper states that the district is nothing but mud, and an Ovens paper says—"The township! what shall we say of the township? It is of mud—muddy!"

An Ovens paper mentions a new locality in which gold has been found, more than enough to "pay for the shot." A gentleman shot some wild duck, and in their gizzards were found several very palpable pieces of granular gold. The story is probable enough.

The half-year's account of the receipts per escort and the shipments as compared with last year are satisfactory.

Received per escorts:	1855.	1856.
April,	177,745 ounces.	213,635 ounces.
May,	120,193 "	223,560 "
June,	227,315 "	173,387 "
	525,253	610,682
Increase on the quarter,		85,420 ounces.
Increase on the six months,		425,382 "

Shipments during the first six months of 1855 and 1856:

For six months of 1855,	1,182,810 ounces.
do. do 1856,	1,583,051 "
Increase this year,	405,241 "

The quantity exported up to the 5th of July is 1,599,424 ounces.

Reducing the first six months' exports to tons, we have—

1854,	44¾ tons.
1855,	49½ tons.
1856,	66 tons.

Exchange is at 1 per cent. discount, and the other charges as before.

The Steiglitz Quartz-Crushing Company have published some of the recent results of their operations as follows:—

From Boxing reef	16	tons	produced	239 ounces.
" "	9	"	"	87 "
" New Chum	6	"	"	63 "
" "	5	"	"	84 "
" "	26	"	"	283 "
	62			756

The Sydney gold and mint returns have lately been published. The results are as follows:—

Received by the Western escort, six months ending the 30th of June,	36,855 ounces.
" " Southern escort,	9,525 "
	46,380

Being less than our weekly average.

The Mint returns are as follows:—The first issue of coin took place on the 23d of June, 1855. There had been issued:—

Up to June 30, 1855.	£48,500
1855—September quarter,	77,000
December quarter,	407,000
1856—March quarter,	513 000
June quarter,	232,500
	£1,278,000

The revenue in 1855 was	£5,408
First six months of 1856	7,004
	12,412

THE GOLD MINES OF CHONTALES.

The Gold Washings of the Department of Chontales have been for a long time a subject of deep interest as well to the Government as to individuals. To determine their real value and to develope as far as possible their richness, several parties have recently gone to the quartz regions, prepared to remain if the washings paid. These parties have met with various success, good, bad, and indifferent, but all agreeing as to the great richness of the quartz and the almost universal presence of fine gold upon the surface. Every bar in the Rio Mico contains a fortune in gold; but it is extremely fine, and to get it requires great skill, perseverance and care in washing it out and gathering it up. The great value of the quartz mines is established beyond a doubt, and several persons able to command capital are about to commence operations there on an enlarged scale. The gold quartz is extremely rotten and soft, and the expense for machinery sufficiently powerful to crush twenty tons per day, need not be half so great as to do the same amount of labor in California. The mining region of Chontales is one of the most healthy portions of the State, and all who have been there agree in representing it as being equal in agricultural richness to any other of the same extent in the world. The hills beyond the Mico are covered with heavy forests, affording every facility for lumber, while the rolling plains on the West afford ample range for vast herds of cattle. This part of the State is destined ere long to become of immense importance, as well from its mineral richness as from its agricultural productions. A full report upon this region is in course of preparation, and will be given in our next.—*El Nicaraguense.*

WHAT HAS BECOME OF THE PRECIOUS METALS?

The following article, although not strictly a subject of mining, yet as it relates to the consumption of gold and silver, which is one product of mines, is a matter entitled to consideration in these pages. It is from the *London Bankers' Circular*, and contains some facts relative to the bullion of Europe, which could not be obtained except by those familiar with the subject abroad.

If some ten years ago a statesman or financier had been asked what effects would be produced upon the money markets by a progressive new supply of gold to the amount of £150,000,000 within the short period of seven or eight years, he would probably have treated the question as an Utopian dream, undeserving practical consideration; but, if pressed to give an opinion, he would with certainty and fair reasoning have enumerated, amongst many other consequences, a vast accumulation of bullion in our monetary reservoirs, the National Banks, and a retrogressive scale in the proportion between the value of gold and silver, from the scale of 1 : 16 to 1 : 12, 1 : 10, and, perhaps, even less, as it existed in ancient times, when the production of the two metals was nearly equal.

Facts have, however, shown a very different result, as may be seen by the following table, giving the amount of bullion in the coffers of the Banks of England and France, at the end of December in each year, from 1848 to 1855, inclusive, and the price of silver and gold in London and Hamburg in the same year:

Years.	Bullion in the Bank of England.	Bullion in the Bank of France.	Bullion in the United States Banks.
	£	Francs.	Dollars.
1848	13,886,000	253,300,000	46,000,000
1849	16,045,000	442,200,000	43,600,000
1850	15,951,000	471,000,000	45,4[illegible]0,000
1851	15,915,000	461,500,000	48,700,[illegible]00
1852	11,361,000	511,400,000	53,200,000
1853	15 462,000	316,900,000	54,400,000
1854	13,619,000	395,1000,00	59,400,000
1855	11,306,000	218,900,000	60,072,000
1856, (June)	12,417,915	286,296,196	65,000,000

Years.	Average price of Silver per oz. in London.	Av'ge price of a Mark of Gold at Hamburg.
	Pence.	Marks Banco.
1848	59 7-16	436 3-16
1849	59 11-16	437
1850	59 15-16	433¼
1851	61	425⅝
1852	60½	428
1853	61½	425⅝
1854	61½	422¼
1855	61½	425½
1856, (June)	61	426½

It is thus clear that the vast supply of gold has by no means exercised a proportionate effect upon the stocks of bullion in the above banks, nor upon the relative values of silver and gold, which have not varied more than 3 per cent.

JOURNAL OF COPPER MINING OPERATIONS.

PITTSBURG AND BOSTON (OR "CLIFF") MINING COMPANY.

The annual report of this Co. has just been issued, and presents the property in a highly favorable condition, both as to the past and the prospects for the future. We gather the following facts, which will be of interest to all who have invested in mining property:

The mineral raised from the Mine during the year terminating on the 30th of November, 1855, amounted, when prepared for shipment, to 2,969,199 lbs., or 1,484$\frac{1199}{2000}$ tons, of the following descriptions:

Mass Copper	1,550,832 lbs.	= 775½	tons.
Barrel Work	735,506 "	= 367¾	"
Stampings	682,861 "	= 341½	"
Total	2,969,199 "	=1,484½	"

The *minimum* monthly product of the year was in Dec., 1854, being 112$\frac{1475}{2000}$ tons, and the *maximum* 148$\frac{384}{2000}$ in July, 1855. The monthly average of the entire year being 128$\frac{1433}{2000}$ against 97$\frac{384}{2000}$ tons, the average of the previous year, or an increase equivalent to 27½ per cent.

In addition to the above 2,969,199 lbs., the product of 1855, there was 26,638 lbs. added by a correction of the inventory of the previous year, making a total of 2,995,837 lbs.

The product in pure copper was 1,874,197 lbs., equal to 62$\frac{56}{100}$ per cent., and producing, when converted into money, \$475,911$\frac{26}{100}$, after deducting the cost of smelting and refining.

The ordinary expenditures for the year amount to the sum of \$256,553-$\frac{23}{100}$, to which should be added \$2,362$\frac{88}{100}$, being the amount of increase in indebtedness at the Mine, and of drafts in transitu after deducting therefrom the increase in the items of supplies and cash at the Mine at the same period,

Making the total amount of		$258,916 11
Which sum, deducted from the earnings,		475,911 26
Leaves a profit for the year 1855, of		216,995 15
The surplus, as reported last year, added		38,125 74
Makes the total of		255,120 89
Loss Dividend, Feb., 1856, $10 per share	$60,000 00	
" Dividend, August, 1856, $20 per share	120,000 00	
" Completion of Cupola Furnace	6,177 15	
" Purchase of Warehouse Pier and Dock at Eagle River	16,000 00	202,177 15
Net Surplus		$52,943 74

While there has been a highly satisfactory increase in the amount of *mineral* produced in 1855, as compared with 1854, equal to 27½ per cent., there has been a still larger increase in the amount of *pure copper;* amounting to 42½ per cent. Increased attention has been paid to the importance of bringing up the percentage to the highest practicable point, so as to save all unnecessary cost in the transportation and smelting of refuse rock. The barrel work has been better cleaned than formerly, and the washing of the rock from the stamping-mill more satisfactorily performed, so that the average percentage for the year 1855, of the whole product as prepared for shipment, was $62\frac{66}{100}$ per cent., against $47\frac{33}{100}$ in 1853, and $56\frac{35}{100}$ in 1854. It is thought that the standard of 1855 can be kept up, but it is not probable it can be brought much above it, without incurring the loss of more copper than would compensate for the transportation and smelting of the refuse rock sought to be detached.

The Mine continues to present the same satisfactory indications as were noted in the last report. Further developments have rendered it quite certain, that what has been denominated the *west* lode *continues downward*, a separate and distinct vein, maintaining, without any material variation, its general character for rich deposits of masses and barrel copper. Instead of being, as was then supposed, a mere divergence from the old lode, upon the floor of amygdaloid referred to, it is now pretty clearly ascertained to be an entirely distinct and separate lode, continuing *south* as well as north, from the point of contact, upon the floor of amygdaloid.

The additional winding engine, which was being constructed at the date of the last report, was put in successful operation in the month of January, and has added very considerably to the facilities for raising the mineral, and freeing the mine of so much of its waste rock as is necessary to bring to the surface, but the great desideratum is additional working shafts. Considering the peculiar geological position of the Mine, overlaid as it is in its course northward by heavy belts of unproductive rock, very hard and exceedingly difficult of excavation, these are necessarily the work of time. No. 4 shaft, nine hundred and forty-three feet north of shaft No. 3, is down two hundred and fifty-one feet, (251,) having been sunk but one hundred and fifty-one feet in the last year. At the same rate of progress it will take two years more to complete it. Until that time, therefore, no additional communication with that end of the Mine can be expected.

The Directors are gratified to be able to direct the attention of such as have been inclined to distrust the enterprise of mining for copper in the Lake Superior district, to the item in the Treasurer's Report, exhibiting the aggregate cash receipts from that source, amounting to $2,120,101.10, out of which there has been paid to Stockholders, in the shape of dividends, the sum of $720,000, or one hundred and twenty dollars per share.

It is also gratifying to be able to express their convictions that the prospects for the future are not less encouraging than the results of the past. The Mine continues to present, as operations are extended, a seemingly inexhaustible supply of copper. The product of the first nine months of the current year is $1229\frac{1644\frac{1}{2}}{2000}$ tons, or $136\frac{1294}{2000}$ tons per month, against $1119\frac{705}{2040}$ tons for the corresponding period of last year, or $124\frac{745}{2000}$ tons per month.

Balance Sheet from the Books of the Pittsburg and Boston Mining Company, January 31, 1856.

The following presents a complete "bird's-eye view" of the operations of the Pittsburg Mine from its first commencement:—

GENERAL EXPENDITURES.

Real Estate, (Mining property, &c.)	$17,242 54		
" " Warehouse and Dock at Eagle River	16,000 00		
" " Furnaces for smelting Copper	25,799 59		
		$59,042 13	
Aggregate Expenditures, other than for Real Estate, for the years 1844 to 1854, inclusive, as per previous reports	$1,149,166 35		

EXPENDITURES FOR 1855.

Cliff Mine	$214,589 00		
Freights on Copper and Supplies	20,456 97		
Commissions	4,358 15		
Insurance	7,029 07		
Interest	2,403 29		
Taxes	1,480 56		
Expense Account	4,146 69		
Loss by sinking of the propeller Napoleon	2,089 50		
		$256,553 28	
			$1,405,719 58

DIVIDE

Paid 1849 to 1855, inclusive		$537,527 50
Cash deposited in Exchange Bank, Pittsburg	$13,522 54	
" remitted J. W. Clark & Co., Boston, to pay dividends	28,449 71	
Bills and Accounts receivable	74,494 62	
Copper and Copper Ore on hand at date of this balance sheet, since then sold and amounting to, (as per contra)	168,206 17	
		$284,673 04
		$2,286,965 25

RECEIPTS.

Capital Stock paid in by Shareholders			$110,905 00
Proceeds of Sales of Copper, Copper Ore and Silver, as per last annual report, 1844 to 1854, inclusive		$1,644,189 84	
Proceeds of Sales of Copper, the product of 1855, at the date of this balance sheet	$307,705 09		
Proceeds of Sales of same, being the residue of the product of 1855, smelted and sold since the date of this balance sheet, and now introduced here for the purpose of presenting, in one view, the sales of the entire year's product	168,206 17		
(See corresponding entry on opposite page,)			
Total product of 1855		$475,911 26	
Total product from the commencement			$2,121,101 10
Bills and accounts payable			55,956 15
			$2,286,969 25

NOTE.—Since the above Balance Sheet was made, Dividends have been declared of $10 per share, February, 1856, and $20 per share in August, making a total of $180,000.

The Directors as usual "are reluctant to hazard predictions in regard to the probable net earnings of the current year. The extensive surface improvements in progress, which served to swell the aggregate expenditures of the last year, will also tend to augment those of the present; and while the product of mineral is likely to be considerably increased, the market value of copper on the other hand is considerably re uced. They look, nevertheless, with confidence for entirely satisfactory results."

NATIONAL MINING COMPANY.—REPORT OF THE AGENT.

National Mine, August 11, 1856.

JAMES M. COOPER, Esq., Secretary and Treasurer.

DEAR SIR:—I herewith submit the following report of operations for the past year, with the present appearance and condition of the mine, accompanied with a longitudinal section of the underground workings, by which it may be seen that a large amount of stoping ground is laid open.

The principal object at the commencement was the development of the mine, by deepening the shafts and connecting them by "drifts." We accordingly sunk the Nos. 1 and 2 shafts about eighty feet under No. 2 adit, when we commenced drifting from each shaft. The driving was continued uninterruptedly until the communication was made. The vein in this level has very materially increased in value, being very profitable stoping ground. The copper which was taken out during the driving of the greatest part of the level was equal in value to the cost of driving, and sometimes far exceeded that amount; and this was also the case in sinking the No. 1 shaft. We were then in a position to stope the "backs" only to a very limited extent, in consequence of hoisting all the water and stuff with the horse whim. It was therefore thought judicious to concentrate all the force that could advantageously work upon driving the No. 3 adit, between No. 2 shaft and the surface; the distance remaining then to be driven was about 300 feet. This work was completed before the "break-up" took place this spring, thus affording us a communication clear through to the surface at that level, by which we have an outlet for water and "stuff;" the latter being now brought out by railway, and drawn by a horse. In addition to the above advantage, there was another object of equal importance, viz., the opening of good stoping ground, which can now be worked advantageously. This accounted for the very small stoping force during the time that these extensive openings were in operation. It was not until April last that this level, No. 3 adit, could be made available for clearing the mine of rubbish, &c.; we have since been stoping the backs with good success. The vein continues rich as the stoping progresses. In driving this level (No. 3 adit,) between Nos. 1 and 2 shafts, the vein was noticed to be very rich in the bottom of the level, "making down;" several pieces of copper, weighing from 500 to 1500 lbs., were cut off from masses that were projecting up from the bottom of the level. This favorable prospect, of having another rich block of ground to stope at a lower level, induced us to consider the sinking of the shafts of the utmost importance. We accordingly made no unnecessary delay in pushing that work; the No. 2 shaft is now sunk 100 feet under No. 3 adit, and the driving for another level commenced.

The No. 1 shaft has a few feet more to be sunk: the reason why this shaft is not so far advanced as the No. 2 is because of the frequent interruption of copper. There is now from two to three tons of copper standing on the foot wall in the last twelve feet sunk, with a good lode yet in the bottom of the shaft. Early next month (September, 1856,) we shall be prepared to drive the level. We may calculate from four to five months for the communication to be made, and the stoping commenced. This block will contain about 600 fathoms of stoping ground, which by appearance in the level above is equal in richness to what we are now stoping. It is almost beyond a doubt that

this will double our present monthly shipments of copper, which have averaged for the last three months eleven tons per month. It might be satisfactory in this place to show the ratio in which our monthly amounts of copper have increased for the last year, beginning with August, 1855, taking together each three-monthly returns consecutively:

	tons.	lbs.
August, September, October,	13	1,854
November, December, January, '56,	15	1,017
February, March, April,	23	1,374
May, June, July,	33	59
Total for the year	86	304

These facts are very encouraging for deepening the mine, as seven-eighths of the whole amount of copper has been raised from the bottom level. The stopes at present indicate results equally favorable with our last month's yield. The Nos. 2 and 3 adits are still driving eastward from No. 1 shaft. Very little stoping has been done in these levels in that direction, but we shall soon commence to stope the "backs," where we expect to find some very profitable ground.

The following is a statement of the work done during the last year, from the end of July, 1855, to the end of July, 1856:

SINKING.

No. 1 Shaft sunk	183 feet	Average price	$16 00 per foot.
No. 2 Shaft sunk	176 feet.	" "	10 00 " "
Total sunk	359 feet.		

DRIVING.

No. 3 Adit driven	650 feet.	Average price	$6 10 per foot.
No. 2 Adit driven	205 feet.	" "	5 97 " "
Total driven	855 feet.		

STOPING.

Amount of ground stoped	475 fathoms.	Average price	$9 00 per fathom.

The above is exclusive of minor matters which are necessarily incidental to mining operations.

Average number of Miners during the year			34
Average wages per man per month			$38 22
Present number of Miners	46		
Present number of Laborers	18	Wages from	$26 to $32
Total under ground	64		

The number of laborers is varied, as circumstances may require.

Yours, very truly and respectfully,

JOHN CHYNOWETH.

MISCELLANIES.

"THE ART PRESERVATIVE."

Printing—letter press printing—the art which takes thought from its living fountain and sends it flashing and radiant on its mission to the minds of men—the art which transmutes rubbish and waste into elements of immortal strength, which makes the clicking of the type and the crashing of the mighty cylinders a more terrible sound for tyranny than all the clicking of firelocks and the thunder of artillery—the glorious art which has made itself the great repository of the mind of the world—"the art preservative of all arts"—is becoming, if it has not already become, one of the Fine Arts. In combinations of elegant forms of lettering, in the display of a cultivated taste in colors, shades, artistic execution, and expressive reliefs in the press work—in every thing, in fact, which makes all art beautiful, the printer's art is fast taking its place as one of the widest fields for artistic display. The numerous examples of this advance in printing which the last few years have produced are familiar to all who have any acquaintance with our publishing and printing houses.

The "illuminated" pages of the olden time, when copyists wore away years in the preparation of a single manuscript "book," the quaint devices, the antique lettering, the playfulness of caprice in throwing letters into a kaleidescopic diversity of forms, the weary work of the earlier illuminated books, and their alternations of red and black lines and words—are immeasurably superseded by the incomparable rapidity of execution of our own modern art. What it will yet become is not certain—what it is now is evident enough.

This apostrophe of admiration for the *mechanical*—we hope the artistic reader will not stop reading because we admire the mechanical—is provoked by a volume which has been laid before us, bearing the imprint of John F. Trow, 377 and 379 Broadway. It is a *Printer's Specimen Book.* It is intended to lay before the public a specimen of ART, as to how and why certain beautiful things are done by certain means, and that the said John F. Trow, his clerks, foremen, journeymen, girls, apprentices, proof readers, devils, and all, are intent upon showing to the world that they are not mechanics but ARTISTS. The faultlessly white paper, the glowing black ink, the elegant lettering, the exquisite wood engravings, the delicate tints which form the borders and illuminations, the profuse variety of ornamentation—the grotesque Arabic and Coptic, Samaritan and Hebrew, and other languages, of which we believe this establishment is the pioneer in this country, and, in short, the *toute ensemble* of this book is a most elegant specimen of the typographic art.

If Mr. Trow wins the eminent success which this book should bespeak for him, he will be known historically among the printers of the country, and will earn what some artists do not, a notable and golden reward. The immense facilities, in the fonts of type of various Eastern and Oriental languages, its large supply of materials, its extensive machinery of every description, adapted to the speedy production of a whole edition in a few days, together with the small army of workers who are employed in its various departments, give it a superior claim upon the patronage and attention of the public.

DIRECT-ACTING PUMPING AND CORNISH ENGINES.

As considerable has appeared relating to the Corning Pumping Engine, the same question has lately excited no small amount of discussion on the other side of the Atlantic. A paper has been read on the subject before the Royal Scottish Society of Arts, by D. Landale, in which he described a direct-acting pumping engine, which, since 1852, has been slowly making headway against the Cornish Engine, on account of its simplicity and cheapness. There are two kinds of this engine, both condensing, high-pressure, and expansive; one

with a 40-inch cylinder and 12 feet stroke, which is simply a Cornish engine turned upside down, the cylinder resting on a strong sole plate over the mouth of the shaft, and the piston-rod attached direct to the forcing set-pump rods. The air pump is small in diameter, with the same length of stroke as the engine, thus doing away with the ponderous beam, parallel motion, and heavy masonry of the cylinder pedestal, lever wall, and engine house, and obtaining any desirable length of stroke by merely adding to the length of the cylinder and piston-rod, thereby increasing the efficiency of the pumps, and making smaller ones do the same work. The second kind of engine is also inverted over the shaft, and secured and attached to its work in precisely the same way. It also uses high presure steam expansively; but its peculiarity consists in there being a constant vacuum above the piston, both during the descent and ascent of the load. During a portion of the descent the piston is nearly *in equilibrio*, having a vacuum on both sides; that under being a partial, and the one above being about 12 1-2 lbs. per square inch, or the common condenser vacuum. As the piston and load continue to descend against this vacuum, a self-acting valve shuts toward the piston, and a full vacuum is acquired by the time the piston has got to the lower end of the cylinder, thus giving a tension or extra pressure equal to 4 tons on the 70-inch cylinder at the moment when it was most required to overcome the *vis inertiæ*. The steam valve is then opened, and high steam admitted for the up-stroke. There are only two double beat valves worked by the engine. The vacuum valve is self-acting, oblong, and hinged, working on the upper part of the cylinder.—*Scientific American.*

PENNSYLVANIA IRON.

Were it not for the coal and iron of Pennsylvania, it would be a question of serious import to find out to what extent the Philadelphia ladies could go on wearing moire antique silks, Mechlin laces, and India shawls, without disturding the balance of trade, and creating a panic in the money market.

Black diamonds and the despised currency of Sparta still exercise an important influence upon the welfare of every nation, and the people who reject coal and iron from their industrial pursuits, must make up their minds to part with their gold, dress their women in homespun, and be content with a low grade in the scale of civilization.

The importance of the manufacture of iron is most strikingly illustrated by taking one week's product of The Railroad and Bar Iron Works, located at Phœnixville (near this city), belonging to the Phœnix Iron Company of this city, the details of which have been handed to us by a friend.

Produced in one week as follows:

First quality of Railroad Iron, 62 pounds per yard	782.76
" Merchant Bar Iron, assorted	196.75
" Prepared Iron, known as No. 1	198.94
" Puddled Bar Iron	608.76
Total tons rolled	1,782.82

☞ Of the above, over 900 tons consisted of railroad iron, merchant bar iron and wrought iron railroad chairs, the market value of which exceeded $55,000. The consumption of coal during the same week at these works was over 1,400 tons. When in full operation they consume some 1,700 per week.

Let it be remembered that this valuable product consisted of materials taken out of the bowels of the earth, every ton of which comes from the neighborhood, within our State, worked into useful form by labor performed by over 2,000 hardy workmen, who spend their earnings in the substantial product of Pennsylvania soil, in supporting their families. It is from such sources, and upon such a foundation, that Philadelphia must draw her life streams and base her prosperity. Home industry, if properly encouraged, is the surest reliance of every community. It is the mother of commerce, and without it commerce is a treacherous and fickle nymph, ready to betray her otaries and impoverish them for the lures of some new Alexandria or Venice upon the discovery of a shorter cut to the land of Ophir.—*Phil. Bul.*